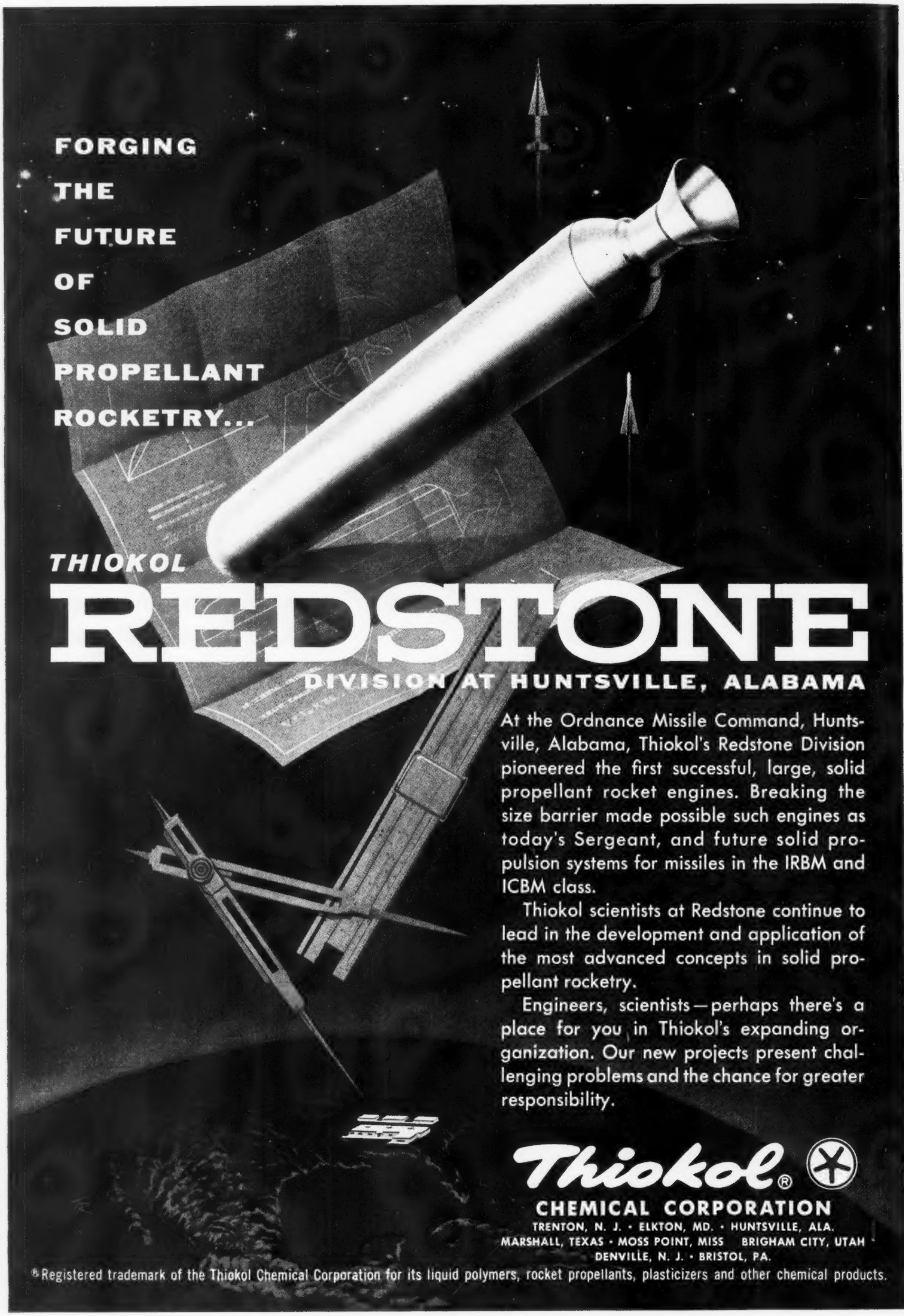
Astronautics

A PUBLICATION OF THE AMERICAN ROCKET SOCIETY

JANUARY 1959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Astronautics

A PUBLICATION OF THE AMERICAN ROCKET SOCIETY, INC

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ASTRONAUTICS is published monthly by the American Rocket Society, Inc., and the American Interplanetary Society at 20th & Northampton Sts., Easton, Pa., U.S.A. Editorial offices: 500 Fifth Ave., New York 36, N. Y. Price $9.00 a year; $9.50 for foreign subscriptions; single copies $1.50. Second-class mail privileges authorized at Easton, Penna. Notice of change of address should be sent to Secretary, ARS, at least 30 days prior to publication. Opinions expressed herein are the authors' and do not necessarily reflect those of the Editors or of the Society.

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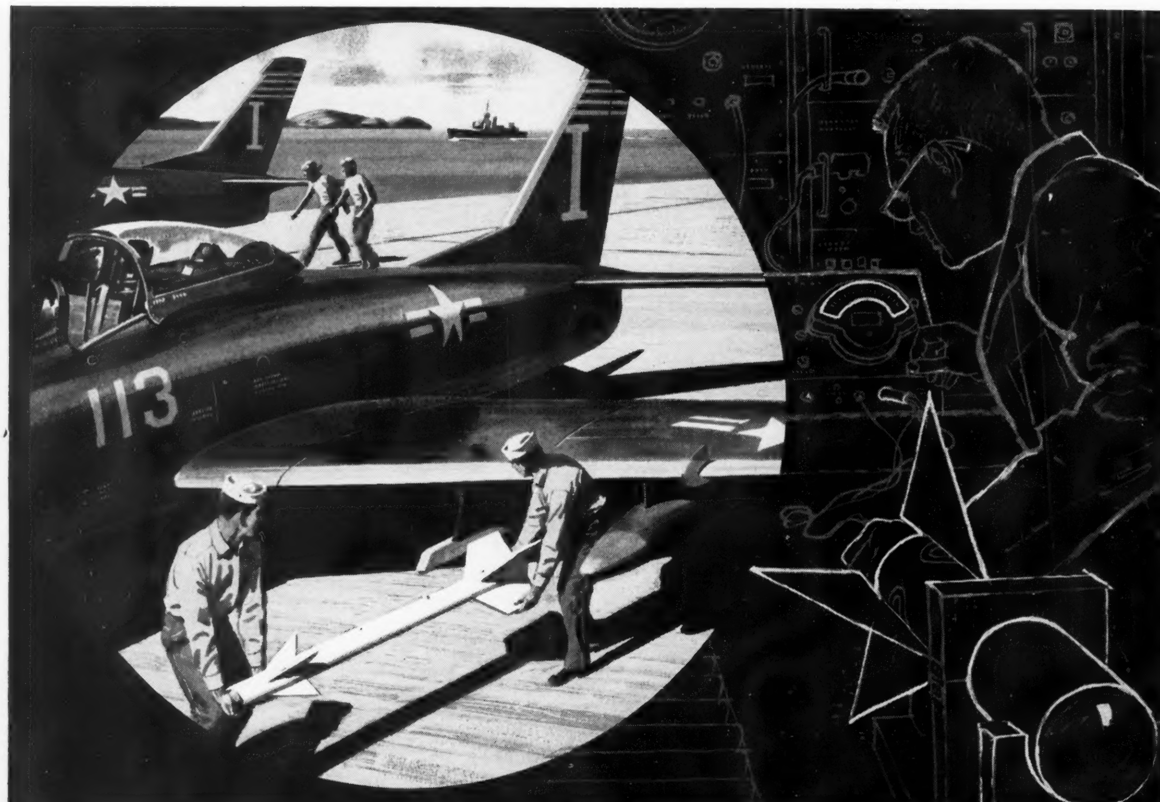

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Astro notes

SPACE PROBES

• JPL Chief W. H. Pickering's comment on Pioneer III—"a scientific success but an engineering failure"—sums up the Army's first lunar probe attempt. The scientific success lies in what appears to be the first real data from the heart of the Van Allen radiation band; the engineering failure in the fact that the probe failed to reach escape velocity. Improper mixture ratio control was regarded as prime factor in premature burnout of modified Jupiter engine which served as the first stage in the Juno II launching vehicle. With burnout coming 3.7 sec early and trajectory angle off by 3$^1/_2$ deg, the 12.9-lb payload reached a velocity just under 24,000 mph and achieved an altitude of some 66,000 n. mi, burning up on re-entry after a 38-hr trip. With Canaveral activity curtailed by the holiday season, the next Army attempt is not expected before the end of the month.

• Newsmen are becoming increasingly irate over the so-called "ground rules" in effect at Cape Canaveral, some saying launches could be covered more easily from Washington. Delays in obtaining information, meaningless press conferences and inability to get anyone to stand still for comment have hampered efforts to pin down the facts quickly. At the press conference following the Dec. 6 shoot, for example, NASA, Army, and JPL spokesmen refused to concede that Pioneer III would fall far short of the moon despite the velocity and angular errors which made such an occurrence extremely unlikely. Preferential treatment for the news agencies and mass circulation magazines is also irking newsmen and photographers.

• Allegany Ballistics Lab solid-propellant engine used as third stage in Oct. 11 AF lunar probe launch is under consideration for future space missions. Considered one of the best high-performance units available, it delivered calculated I_{sp}, insofar as can be determined, in Oct. 11 launch, contrary to the note in last month's Capital Wire column (page 12).

SPACE AGENCIES

• Transfer of JPL facilities from Army to NASA had this interesting sidelight. In addition to the Army agreeing to make part of ABMA's R&D capacity available to NASA, key ABMA scientists and engineers will be allowed to serve on NASA technical committees and advisory groups or as individual consultants on NASA projects.

• NASA is now forming technical advisory committees to replace similar NACA committees. Some dozen committees will cover fluid mechanics; aircraft aerodynamics; control, guidance and navigation; chemical and nuclear energy sources and processes; mechanical and electrical power systems; structural loads, design and dynamics; materials; and aircraft operating conditions. A special committee, headed by W. Randolph Lovelace II, has already been formed to advise on life sciences and human factors.

• Congressional committees evidence concern that NASA's reopening of bidding for development of the million-pound thrust engine, which ARPA originally awarded to Rocketdyne, will cause considerable delay in the program.

• Meanwhile, ARPA, scheduled to pass out of the picture in March, shows signs of being more than a one-reeler, and is drawing strategic fire from the Air Force for allegedly putting ARPA labels on AF projects under its supervision.

MISSILES

• DOD, reviewing the ever-quickening pace of missile technology, and heeding the bell of operational analysis as well as the budgeteers, began the agonizing task of putting the missile program into perspective in a big way. Cuts are expected across the board for air-breathing missiles, and there will be no further major support for Regulus II and Mace. Aircraft taking cuts, if not being dropped, include Convair F-106 and B-58 Mach 2 bomber, the Hustler. Rascal was cancelled as North American's Hound Dog received a contract for production. Thor and Jupiter will retire after current production contracts, which will deliver some 60 Thors to Great Britain and 45 Jupiters to Italy. Titan slipped and Polaris rolled with budget punches.

• Despite the journalistic furor over a nuclear-powered aircraft, DOD appears holding firm in limiting this program to $200 million a year. The program, which has drawn a billion dollars so far, entails many technical and military problems.

• Navy, however, is expected to contract for development of Eagle, its versatile air-to-air missile, this month, after convincing even DOD budget birds that Eagle cannot be matched by extensions of present weapons, such as the AF-Hughes GAR-9.

• Also, Army has plans for a light IR-homing ground-to-air missile (Redeye) for use against low-flying aircraft and helicopters.

• Drones continue to draw contracts, with Redstone Arsenal accepting bids on both subsonic and supersonic designs. Navy and Air Force are pushing a joint program on a multi-use drone target with a top speed of Mach 3.

RESEARCH

• Work by the USAF Cambridge Research Center on the little-known "exploding wire phenomenon" may establish a new approach to the problem of spacecraft propulsion and possibly to controlled thermonuclear fusion itself. By discharging enormous currents through tiny wires, the wires can be made to vaporize into a plasma of 50,000 K or more. This plasma could be directed by an external magnetic field to produce thrust for propulsion. The technique conceivably could lead to thermonuclear fusion, but the big drawback has been the failure to create a "pinch effect" in the plasma. This is due to the much greater plasma densities of the exploding wire compared with those encountered by Project Sherwood in the AEC program.

IAF

• Tenth IAF Congress will be held in London Aug. 31 to Sept. 5. Deadline for abstracts is May 1, for the papers themselves June 1.

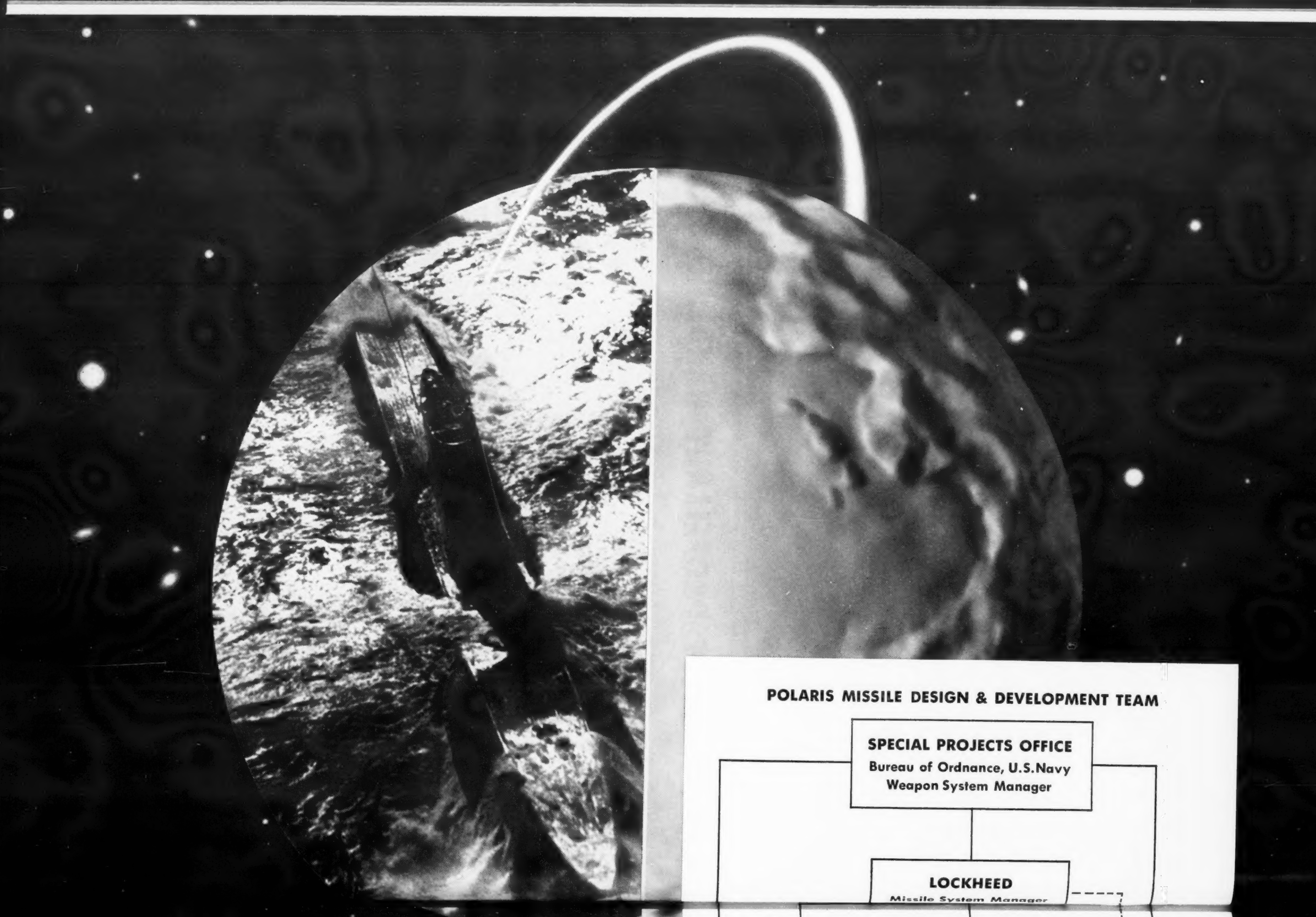
EDUCATION

• MIT is holding a graduate seminar on the political and economic aspects of space flight. ARS past president George Sutton, Hunsaker professor of aeronautical engineering at MIT, is one of the seminar professors.

• Adding some little boost to already waning interest in supporting research at the source, NSF awarded 302 Science Faculty Fellowships and 82 Senior Postdoctoral Fellowships in the sciences for FY '59. James R. Killian Jr. recently estimated that the rapidly rising number of students bound for the universities and colleges would soon make the number of Ph.D.'s going into the teaching profession only one-quarter of those needed for a sound national educational program, and again urged more support of research and higher educational facilities.

AMATEUR ROCKETRY

• Adding its weight to growing calls for restrictions on amateur rocketry, CAB has proposed, through pending amendments to civil air regulations, to prohibit firing of rockets within 5 mi of airports and under or into controlled air space.



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Capital wire

News highlights from Washington

SPACE RADIATION

• The crucial question of the intensity of space radiation beyond 1300 miles was scheduled to receive an answer last month as the Army prepared to launch its first lunar probe, containing two peanut-sized Geiger counters devised by James A. Van Allen. Before the launch, the scientist speculated that the radiation might climb to at least 100 roentgens and possibly 1000 roentgens in the unknown area between Explorer IV's peak altitude and the 11,000-mile level at which useful Pioneer I measurements began. Dr. Van Allen also cautioned that the low counting rates from Pioneer I—5.5 roentgen at 11,320 miles and tapering off steadily—may be deceptive, because there is evidence that the argon in the pressurized ion chamber leaked.

• Fred Singer, Univ. of Maryland physicist, proposed a complex shield as one answer to the radiation threat in a paper delivered at the San Antonio space conference in November. He suggested a three-layered shield: A thin layer of lead on a sub-stratum of tin (also serving as a meteor bumper); the skin of the vehicle itself, made of aluminum, magnesium or titanium; and, finally, an inner layer of hydrocarbons (such as rocket fuel) to catch fragments.

SATELLITES

• At the direction of ARPA, the Air Force has sharply reduced the scope of its WS-117L Sentry reconnaissance satellite program. A variety of satellite technology projects originally included in Sentry have been reorganized as a separate program tentatively labeled "Discovery." A total of eight to ten Discovery shots are planned, all from Vandenberg AFB, Calif. The shots will involve low-altitude orbits of short duration, with controlled recovery an important objective. Included in the program are animal experiments, spatial orientation and stabilization, and a variety of "precursor" experiments to Sentry.

• Initial workhorse in the Discovery program will be Thor-Hustler, with Atlas shots coming later. Thor-Hustler consists of a standard Thor first stage, with a Lockheed-developed second stage employing a modification of the rocket motor developed by Bell Aircraft for the powered bomb pod of Convair's B-58 Hustler. The powered pod was cancelled, but work continued on the engine for the space application. Payload capacity of Thor-Hustler is said to be in excess of 500 lb, exclusive of the spent second stage.

• Those two Thor-Able-I vehicles which ARPA earmarked for NASA last August will be used to place 100-lb payloads in tremendous orbits, with apogees ranging out to 40,000–100,000 miles. One is assigned to lug an entire cargo of radiation instruments. All told, NASA expects to fire between eight and twelve satellites and space probes in 1959, pursuing a deliberate approach, rather than the "shoot or bust" policy in operation up to now.

• The mysterious failure of Explorer VI, assigned to put a 12-ft aluminum sphere in orbit in October, has largely been solved. At 110 sec after launch, the payload and perhaps the whole fourth stage tore loose from the upper stage spinning bucket of the Jupiter-C. This was indicated by doppler velocity measurements which showed that the payload transmitter stopped accelerating after 110 sec, while the transmitter in the Redstone booster continued to gain speed. The Army speculates that a trace of air left in the packed sphere may have permitted an off-center shift in the rapidly spinning payload, leading to intolerable vibrations and the fracture, but NASA officials think the payload got too hot during the launching.

DETECTION

• Disregard reports that the Russians have launched a "phantom" satellite. No such launching is known to U. S. intelligence officials, nor is there any indication the Russians have attempted a lunar probe. One source of such reports is radio amateurs trying to trace Soviet sputniks. Lacking expensive receiving equipment, they have confused the 20-mc time signal of the government's radio station, WWV, for the lower frequency used by the Russians.

• ARPA has undertaken a program to examine the possibility of detecting ballistic missiles over the entire span from launch to re-entry. It will look at the ballistic missile with a variety of airborne, shipborne and ground equipment at the Cape Canaveral range. Included are radar, IR and optical devices, and particularly radio receivers. Latter may hold the best hope, since a large rocket engine may radiate a characteristic radio "signature" subject to long-range detection, like nuclear blasts. Development of compact detection systems may give rise to "early warning" satellites.

MILITARY BUDGET

• Convair's 6300-mile Atlas shot in November was a master tactical maneuver in the annual scuffle for Uncle Sam's dollars. It was calculated to serve as a ready excuse for Titan curtailment, as well as justify full reliance on Atlas. The shot was actually a demonstration—not a test. It proved nothing which had not been shown in the 3000-mile shots of the overloaded Atlas-B vehicles last August. Contrary to many reports, there was no re-entry, the vehicle dispensing with a nose cone in order to accommodate half its usual cargo of telemetry. Project officials say flatly that full-range re-entry isn't necessary at Cape Canaveral because the August shots have already proved that capability.

• Another casualty of the fiscal 1960 budget may be the clustered rocket engine of 1.5 million pounds thrust which the Advanced Research Projects Agency assigned the Army for development. Although the monster engine, utilizing eight Rocketdyne powerplants similar to those employed in the Thor and Atlas, could be achieved more rapidly and cheaply than the single-chamber engine under development by NASA, the budgeteers feel it's an expensive luxury. They doubt U. S. will be ready for big man-in-space ventures as soon as the clustered engine materializes, and are inclined to place their bets on the NASA program.

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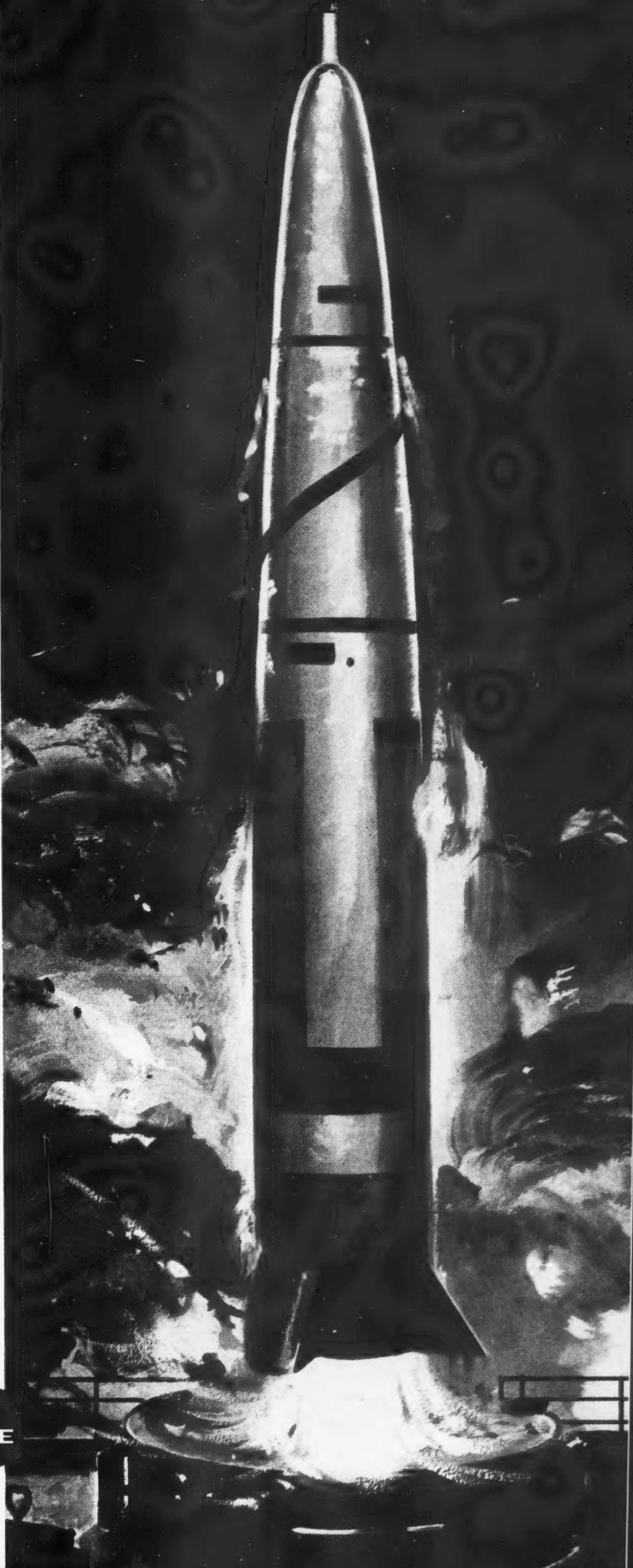


Left to right, Wernher von Braun, Hubertus Strughold, and L. R. Shepherd chat during a coffee break at the San Antonio meeting.

Maj. Gen. Otis O. Benson Jr., SAM Commandant, opens symposium.

Space Medicine Symposia Span Two Continents

SPACE medicine held the spotlight in meetings on two continents in October and November, with important symposia held both in England and in the United States. The British Interplanetary Society Space Medicine Symposium, held in London, Oct. 16–17, brought together about 100 experts, with the Second International Symposium on the Physics and Medicine of the Atmosphere and Space, held in San Antonio, Tex., Nov. 10–12, under the sponsorship of the AF School of Aviation Medicine and the Southwest Research Institute, drawing an attendance of close to 800.

The BIS symposium, which attracted specialists from Great Britain, the U.S., and a number of European countries, was termed "quite successful" by Leslie R. Shepherd, Chairman of the BIS Council, who also attended the San Antonio meeting. Among the many interesting papers presented at the symposium were those on "Space Transport of Life in the Dried or Frozen State," by A. S. Parkes and Audrey U. Smith of the British National Institute for Medical Research; "Blast Studies on Explosive Decompression," by Carl-Johan Clemedson of the Swedish Institute of National Defense; "Space Feeding Problems," by S. W. F. Hanson, British Ministry of Agriculture, Fisheries and Food; "Consequences of Weightlessness and Artificial Weight," by M. P. Lansberg, Netherlands Aeromedical Center; "Impairment of Human Performance in Control," by K. F. Jackson of the RAF Institute of Aviation Medicine; and "Man's Thermal Environment During Interplanetary Travel," by J. Billingham.

The San Antonio meeting, most truly lived up to its "international" billing by presenting papers by Belgian, British, German, and Swiss authors, as well as by a number of American experts. In all, 40 papers were crammed into the three-day meeting, with the consensus of opinion being that it might have been better to eliminate some papers and permit adequate time for discussion, as at the first symposium in 1951. Another oddity of the meeting was the fact that Scott Crossfield was the only test pilot present, and a good deal of the material presented dealt with the problem of man in space.

Two of the technical sessions at the meeting were devoted to environment, covering such subjects as radiation, micrometeorites, composition of the upper atmosphere, and gravitation. Other sessions were devoted to vehicles, medical problems, rescue in space, and the planets. Session chairmen and participants read like a "who's who" of the astronautics, space medicine and upper-atmosphere research fields. For example, among the session chairmen were Hugh Dryden, NASA deputy administrator; Alan F. Waterman, National Science Foundation director; Maj. Gen. Bernard A. Schriever, Commander, AF Ballistic Missile Div.; Hubertus Strughold of SAM, who played a major role in putting together the program; and Fred L. Whipple, director of the Smithsonian Astrophysical Observatory.

As far as the papers themselves were concerned, major interest centered on radiation, and the first paper presented, by James A. Van Allen of the State Univ. of Iowa, on the latest radiation data from U.S. satellites, naturally aroused a good deal of interest, as did the review by Fred Singer of the Univ. of Maryland on the effects of environment on space vehicles, and papers by Herman J. Schaefer of the Navy School of Aviation Medicine on radiobiological implications and by Cornelius A. Tobias of the Univ. of California on radiobiological studies with accelerated heavy ions.

A good deal of interest was also shown in the foreign papers. Presenting papers were Marcel Nicolet of Belgium, IGY secretary-general; Walter Dieminger of Germany, director of the Max Planck Institute for Aeronomy; Jakob Eugster of the Univ. of Zurich, Switzerland; and Dr. Shepherd, whose survey of space propulsion systems came in for a good deal of favorable comment.

Another highlight of the meeting was Wernher von Braun's paper on satellite and moon probe launchings and trajectories.

The symposium banquet was highlighted by an address by Senate majority leader Lyndon B. Johnson (D., Tex.) just a few days before his appearance at the UN to discuss international astronautical cooperation.

—I.H.

International line-up. Delivering papers are, left to right, James A. Van Allen, Jakob Eugster, Fred Singer, and Walter Dieminger.

For the record

The month's news in review

Nov. 4—AF disclosed a rocket-powered test vehicle reached a peak speed of 2853 mph (about Mach 4.8) during a test run last September at Holloman AFB.

Nov. 5—Thor missile, heart of AF Pioneer, is destroyed shortly after launching.

—Army completes its Redstone missile test program with a reportedly perfect 250-mile shot across the Atlantic.

Nov. 8—Third AF Pioneer moon shot climbs 1000 miles and drops back to earth after third-stage rocket fails to ignite.

Nov. 10—Army says Nike-Hercules made first kill of a target at more than 20 miles high last week.

Nov. 12—House Government Information Subcommittee issues summary of an AF Inspector General report blaming faulty procurement policies for delays and waste in AF's development of long-range missiles.

Nov. 13—President Eisenhower backs AF's refusal to turn over to Government probers full report criticizing service's missile program.

—U.S. urges UN to set up a committee to promote international cooperation in peaceful uses of outer space.

Nov. 15—AF announces recovery of a recording capsule ejected from an Atlas missile successfully fired last Aug. 2. Device, found in Caribbean Oct. 17, taped information on nose cone reentry.

—ICSU Committee on Space Research (COSPAR) elects Prof. H. C. van der Hulst, of the International Astronomical Union of the Netherlands, president. Also draws up a constitution and bylaws.

—Naval Research Laboratory says Explorer I has covered 104,170,075 miles in 3475 trips around the world since its launching Feb. 1.

Nov. 17—AF sends full-powered Atlas 3000 miles.

Nov. 18—NASA postpones Vanguard satellite launchings until after IGY ends.

—AF discloses it is working on a missile, called the Hare, which would fly on atomic oxygen scooped up from the atmosphere, and at about 900 mph at some 60 miles altitude.

—AF Navaho explodes soon after launching.

Nov. 19—Army gives Smithsonian Institution recovered Jupiter-C nose cone which traveled some 270 miles high in August 1957 firing.

Nov. 24—UN General Assembly's Political Committee okays establishment of an 18-nation Committee on the Peaceful Uses of Outer Space, disregarding Soviet threat of a boycott.

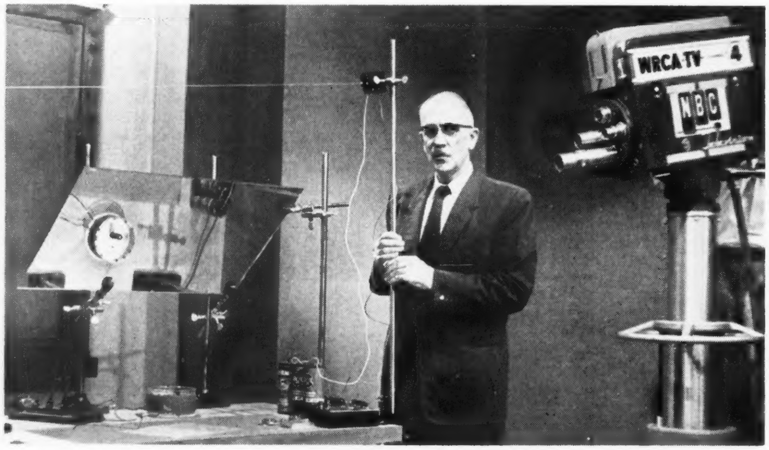
Nov. 25—NASA reveals plans for eight space probes in 1959, with Mars and Venus among targets.

—Pentagon announces that new $100 million rocket base at Vandenberg AFB, Calif., will begin operations early in December.

Nov. 27—Navy balloon flight for high-altitude study of Mars is temporarily canceled.

Nov. 28—AF Atlas is fired full-range of more than 6000 miles for the first time.

Nov. 29—AF tags Rascal missile obsolete, will replace it with Hound Dog as armament for strategic bombers.



Continental Classroom

Harvey E. White, professor of physics at the Univ. of California, stands in NBC Television's Continental Classroom, a coast-to-coast 6:30-to-7:00 a.m. TV physics course for students and laymen which swings into high gear on Feb. 11 with a series of lectures on atomic and nuclear physics. This series may be followed by one on astronautics.

Aviation Writers Sponsoring Forum on Astronautics

Members of ARS are invited to attend a forum entitled "On the Threshold—Jets and Space," being held by the International Society of Aviation Writers at Rockefeller Institute in New York at 10:30 a.m. Jan. 14, 1959. Panel members include Lloyd Berkner, Homer Stewart, Fred L. Whipple, and moderator Jerome Lederer, managing director of the Flight Safety Foundation.

Guggenheim Fellowship Applications Due

Science or engineering students, residents of the U.S. or Canada, should file qualifications by March 1, 1959 at Daniel and Florence Guggenheim Centers at Princeton Univ., California Institute of Technology or Columbia Univ. to compete for the 20 tuition-and-stipend fellowships available during 1959–60.

COVER: *Many new and strange optical materials are being pressed into service by the pioneering infrared designers of today. This month's cover shows three: A hemispherical dome carved from a single 6-in. silicon crystal to cap the nose of a heat-seeking missile; a crimson arsenic-trisulfide lens for an IR surveillance system; and a sphere of special lead silicate glass destined to become a diminutive IR dome.*

Astronautics

JANUARY 1959

The President's Letter

While the newly elected head of a society which has just completed its most successful year can usually only look back in awe and look ahead with fear and trepidation, such is not the case with ARS. Prospects for the coming year have never been better. Membership growth is expected to continue at the 1958 pace; new Sections and Student Chapters will be formed as they are needed; our publications, too, will continue to grow.

It is in the area of member services, however, that the most important steps are being taken. Expansion of the Society's Technical Committee setup will not only insure the selection and presentation of outstanding papers at national and regional meetings, but will also permit more widespread and active participation by individual ARS members in planned meetings.

Another step toward this end is the scheduling of a number of special subject conferences this year. Already set are: A Flight Testing Conference at Daytona Beach March 23–25; a Man-in-Space Conference at Hampton, Va. April 20–22; a Controllable Satellites Conference at MIT April 30–May 1; the Gas Dynamics Symposium at Northwestern Aug. 24–26; and a Solid Propellants Conference at Princeton Sept. 24–25.

On page 60, also, you will find an announcement of a title change for Jet Propulsion, henceforth to be known as the ARS Journal, certainly a more suitable title for a publication which now embraces a wide field of present-day scientific disciplines. Further expansion of the Journal may be expected in the months that lie ahead.

It is indeed an honor and a privilege to serve the Society in this important and exciting year.

—Col. John P. Stapp
President, American Rocket Society

Is Newton's law of gravitation really universal?

An examination of the interactions between clusters of galaxies suggests Newton's law breaks down at distances considerably smaller than expected in any of the current cosmological theories

By Fritz Zwicky

CALIFORNIA INSTITUTE OF TECHNOLOGY, PASADENA, CALIF.

The two hats worn by Fritz Zwicky—one as professor of astrophysics at Cal Tech, the other as staff astronomer at Mt. Wilson and Palomar Observatories—both came into use in the writing of this fascinating article. Author of three books and more than 200 scientific papers in American, English, Swiss, French, and German scientific journals, Dr. Zwicky came to this country from Switzerland in 1925 as an international research fellow in physics at CalTech, staying on until 1942 as assistant professor and associate professor. From 1942 to 1949, he built up a large research department for Aerojet Engineering Co., as director of research, and he is now chief research consultant for Aerojet-General. Dr. Zwicky holds the Presidential Medal of Freedom for his evaluation as a member of the AF Scientific Advisory Board of the Japanese and German WW II technical effort.

DURING the past 20 years, the author's development of the morphological method of total research, which systematizes the basic elements of scientific research and discovery, has been singularly successful in foreseeing and in planning future developments on the basis of sound technical prophecy.

In this period, the morphological approach, which clearly goes beyond the capabilities of conventional scientific research, has been responsible for a number of major developments in the field of jet propulsion, for the invention of new rockets, aerial jet engines, hydrojet engines, high-energy and ultra-energy propellants, fragment chemistry, metachemistry, etc.

Morphological Method of Research Used

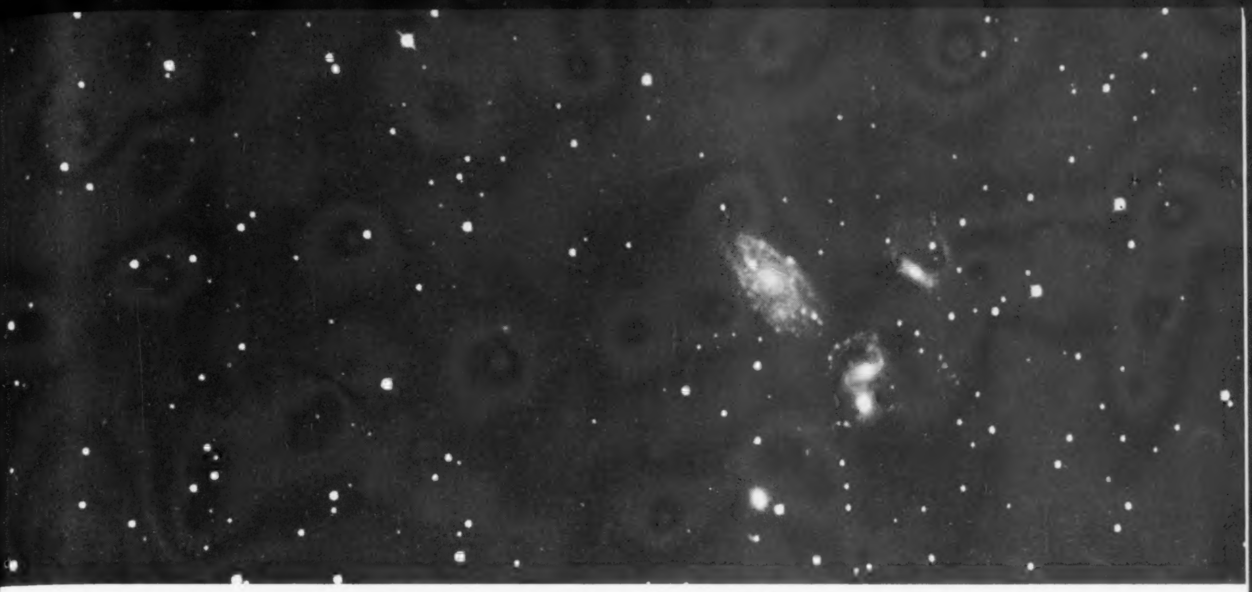
In addition, application of the morphological method to Newton's universal law of gravitation has led to the unexpected discovery that the law is not universal, but that it breaks down if the interacting bodies are separated by distances greater than a few million light years.

The particular aspect of the morphological method which has led to the discovery of deviations from Newton's law may be called the method of the extremes. In this approach, the limits of well-known phenomena and physical laws are explored, and regions are examined which lie far outside the realms within which such phenomena are usually studied.

To understand how the above conclusion was reached, it is first necessary to review briefly the history of Newton's law of gravitation.

Newton postulated that "every particle of matter in the universe attracts every other particle with a force varying inversely as the square of their mutual distance and directly as the mass of the attracting particles." In combining the law of gravitation with his equally famous laws of motion, Newton and his successors accounted for all the observations then available on the motions of the planets, their satellites, and the comets.

Elaborating and extending Newton's theory, Lagrange, Euler, Laplace and others developed powerful mathematical methods for



Stephan's Quintet, a cluster of galaxies, taken by the 200-in. telescope of Mt. Wilson and Palomar Observatories.

the investigation of the stability of the planetary system and for the effects of mutual perturbations of the various planets on their individual orbits. As a crowning result of the combined analytical and observational exploration of the solar system, the perturbation theory, in the hands of Adams and Leverrier, led to the discovery of the planet Neptune.

Even before this discovery, attempts had been made to test the validity of the universal law of gravitation for celestial bodies located far outside the solar system. As early as 1830, for example, Savary showed that the motions of the components of some double stars could be interpreted quantitatively on the basis of the law.

During the past century, a great variety of theoretical and observational investigations have been carried out on the problem of the universality of Newton's law. These developments involved the detailed study of small perturbations of all kinds, of the three-body and many-body problems, and of experimental tests of the law for terrestrial objects.

Observational tests made up to a few years ago have more or less proved the strict validity of Newton's law of gravitation for the following two ranges of conditions:

1. The gravitational attraction between two masses m_1 and m_2 is given by the expression for the force Gm_1m_2/r^2, where $G = 6.67 \times 10^{-8}$ g^{-1} cm^3 sec^{-2} and r is the distance from m_1 to m_2, provided that r is not larger than about 1 million light years, or 10^{24} cm, and not much smaller than 1 cm.

2. It does not seem to matter whether the two masses m_1 and m_2 are located near us or as much as several hundred million light years away.

These conclusions have been drawn from observations of the motions of components of double stars and investigations of the statistical distribution of galaxies in clusters of galaxies. Needless to say, tests for the law's universality made for celestial objects outside our own solar system have been few, and to some degree uncertain. While much remains to be done, present information may be summed up as follows.

Checks of Kepler's laws of motion, and therefore of Newton's law of gravitation, have been carried out for the components of double stars lying at distances from Earth not exceeding about 700 light years. The proof of Newton's law is naturally restricted to separations between the components of double stars which are not greater than the dimensions of the solar system.

In fact, when the period of revolution of a double star becomes greater than a few hundred years and separation of its components grows much larger than one light day (2.57×10^{15} cm), the time for accurate recording of the motion becomes too short to assure the necessary precision. Thus, proof of the law, as far as it can be derived from double stars, is very limited in range.

No Real Evidence Until 1930

Peculiarly enough, up to about 1930, no real evidence was ever presented that Newton's law holds for separations of interacting masses which are greater than, say, a light year, or for bodies located outside a radius of 700 light years from earth.

By applying the principles of dimensionless morphology, i.e., relying on the identification of certain types of objects, such as galaxies, and counting them and determining their distribution, the author has for a number of years (CONTINUED ON PAGE 74)

TARGET PLANET	59	60	61	62	63	64	65	66	67	68	69
VENUS	3/6 to 17/6	-	11/1 to 25/1	8/8 to 22/8	-	18/3 to 1/4	27/10 to 10/11	-	7/6 to 21/6	-	1
MARS	-	8-10	-	9-11	-	11-1		12-2		-	1-3

Interplanetary probes: Three problems

Limited opportunities for launching vehicles to Mars and Venus with the present state of the art, flight path errors, and midcourse guidance requirements point up the difficulties involved in such missions

By Krafft Ehricke

CONVAIR, A DIVISION OF GENERAL DYNAMICS, SAN DIEGO, CALIF.

Krafft Ehricke, an inspired advocate of space flight, is assistant to the chief engineer of Convair-Astronautics. After graduating as an aeronautical engineer in Berlin, Germany, he worked at Peenemuende during WW II on the V-2 project. He took a U. S. Army contract in 1945, working from 1947 to 1950 as a research engineer on ramjet and rocket systems at Ft. Bliss, Tex. and from 1950 to 1952 as head of the Gas Dynamics Section at Redstone. From 1952 to 1954 he was an engineer with Bell Aircraft Corp. He joined Convair in 1954.

ROCKET probes into interplanetary space will extend current scientific studies with satellites and lunar probes, will orient the development of equipment for space flight, and will lay the groundwork for manned interplanetary expeditions by discovering survival factors and helping to define the most profitable missions.

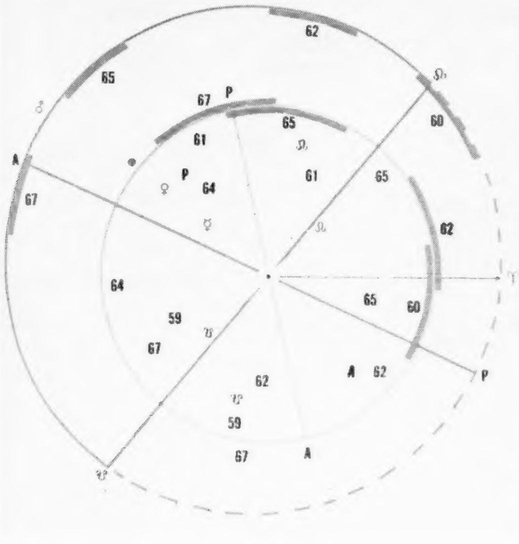
Probes to Venus and Mars among others will serve these purposes well. We will have the hardware for these probes, and for conducting instrumented research in the entire solar system, in the near future.

When might we launch interplanetary probes? It is interesting to note that, in the entire next decade, there exist only five opportunities for launching probes to Mars and only seven for launching probes to Venus. We assume, of course, the energy limitations of modified ICBM engines as boosters and upper stages with high-energy propellants. The table above lists the opportunities by date.

The right constellation for departure to Mars was this past August/September. The next launching period to Mars will occur in September/October 1960. From then on, opportunities come about every 25 months. The next period for launching a probe to Venus is June, 1959.

Our purpose here is to sketch briefly the nature of these limitations in launching period, to point out what errors affect flight path, and what will be required of midcourse guidance.

LAUNCHING TO VENUS & MARS CONSTELLATIONS
1959-1967



The limited opportunities for launching interplanetary probes arise in part from matching the energy available in presently available rocket systems with the most favorable relative positions of the planets. Of particular interest are planet velocities and the eccentricity and inclination of planetary orbits, which can be found in any standard text on astronomy.

The planet orbits are noncoaxial ellipses, and therefore the minimum-energy transfer orbits between two planetary terminal orbits are not necessarily exactly cotangential, nor do they cover a center angle of 180 deg (Hohmann transfer ellipse). Of still greater significance is the inclination of the terminal orbits.

Consider the projection of two terminal orbits on the celestial sphere, as shown below right. Let "I" be the departure orbit, "II" the target orbit. The line of intersection (nodal line) is marked ☊ ☋.

Suppose we wish to transfer from Orbit I to Orbit II. We are interested in the correlation between the transfer center angle (η)—i.e., the angle, subtended at the sun's center, S, between departure point in Orbit I and arrival point in Orbit II—and the required inclination (i) between the plane of Orbit I and the plane of the transfer orbit. It is obvious that if you travel from ☋ to ☊, an $\eta = 180$ deg transfer can be made without leaving Plane I (nodal transfer)—i.e., a minimum energy transfer.

The opportunity for a nodal transfer, however, is rare. If the departure point deviates from a node by an angle (φ) at, say, Station I, as shown on the diagram, then, if inclination is to be zero, the transfer angle becomes $180° - \varphi_1$. If we now start rotating this transfer orbit about its nodal line, we see that the distance between Station 2 and the intersection of transfer orbit with Orbit I decreases steadily, until inclination = 90 deg. That is, transfer center angle increases and comes as close as possible to 180 deg when inclination = 90 deg.

But, in this case, we are far from a minimum energy transfer, although transfer angle is as close as possible to 180 deg, because much energy is required to tilt the transfer orbit plane with respect to the original Orbit I.

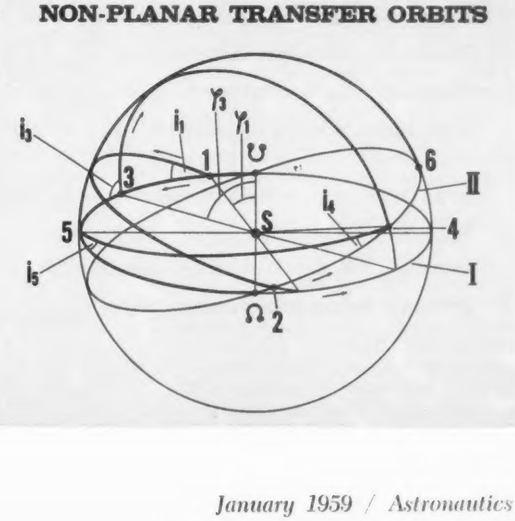
In general, if we designate the distance between Station 2 (or 4) and the subsequent intersection point with Orbit I (i.e., the difference between η and 180 deg) as l, we find that Equations 1a, 1b, and 1c, as given in the table on page 22, hold for the transfer center angle.

In these equations i_{II} is the inclination of Orbit II with respect to Orbit I. The angle, l, is therefore a function of i_{II}, i, and φ. The smaller i_{II} and φ, the more will η approach 180 deg. Conversely, the smaller η, the smaller can be the inclination for a given constellation (e.g., transfer 5-4 in the diagram at bottom of this page). If φ is large (e.g., transfer 3-4 on the same diagram), then η may deviate considerably from 180 deg, even if $i = 90$ deg. In the extreme case where $\varphi = 90$ deg, one has $\eta = 180 - i_{II}$ for $i = 90$ deg (transfer 5-6).

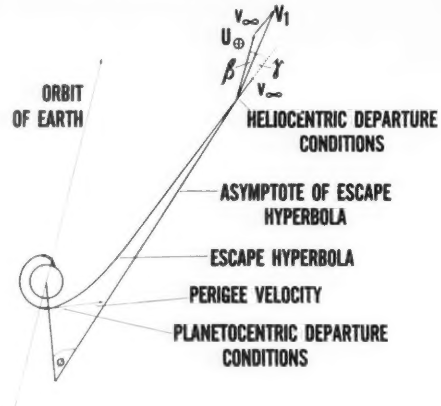
It is therefore important to keep in mind that in most cases the transfer center angle is less than 180 deg even if the terminal orbits are exact circles. Ellipticity of the planet orbits also contributes to deviation from $\eta = 180$ deg, even if the orbits are coplanar.

Because the terminal orbits will not be in the same plane, the transfer orbit may have to be canted. A faster orbit which requires less canting may be less expensive than a slower orbit. This is certainly true for transfer orbits which involve only

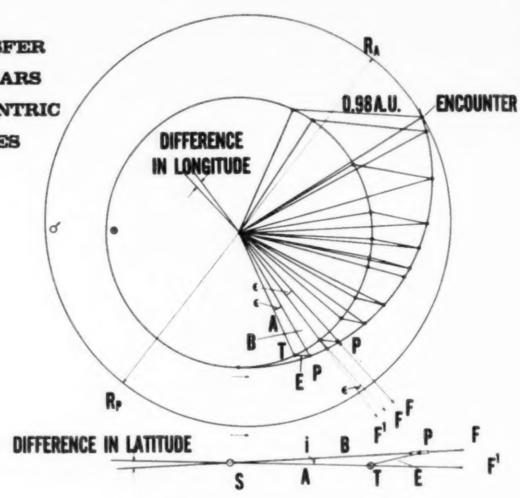
NON-PLANAR TRANSFER ORBITS



PLANETOCENTRIC AND HELIOCENTRIC DEPARTURE CONDITIONS



FAST TRANSFER ORBIT TO MARS IN HELIOCENTRIC COORDINATES



hyperbolic encounter and not capture with the target planet. In hyperbolic encounter, no energy is spent near the target planet.

The energy increase required by departing along a faster orbit is quite small, especially if the departure is cotangential. Equation 2 describes the total departure velocity with respect to the Earth. Local parabolic velocity (Equation 3) is given with respect to the Earth-Moon system; $K_{☾}$ is the gravitational parameter of the combined Earth-Moon mass; r_{st} is the starting distance from the center of the Earth (i.e., the distance where the hyperbolic departure impulse is given).

Equation 4 of the table gives hyperbolic excess required for a given heliocentric departure velocity vector (V_1) inclined at an angle (β) with respect to the Earth's direction of motion. Equation 5 defines the velocity increment required to cant the orbit by the inclination angle (i).

It can be seen that hyperbolic excess velocity can become very large if departure angle (β) is large. On the other hand, the orbit-canting velocity requirement (Δv_i) can become very large even for an inclination much less than 90 deg.

By carrying out all maneuvers at departure near Earth, no additional (CONTINUED ON PAGE 42)

TABLE OF EQUATIONS

Center angle of transfer path: $\eta = 180° - l°$ (1a)

$$\text{generally } l = \sin^{-1}\left[\frac{\sin i_{II}\sin\varphi}{\sin[\cos^{-1}(\sin i_{II}\sin i\cos\varphi - \cos i_{II}\cos i)]}\right] \quad (1b)$$

For small angles i_{II} and i: $l = \sin^{-1}\left(\frac{i_{II}}{i}\right)\sin\varphi$ when i_{II} small for ♂ and ♀: $i \lesssim 10°$ (1c)

Hyperbolic departure velocity: $v^2_{st} = v^2_p + v^2_\infty + (\Delta v_i)^2$ (2)

Hyperbolic vertex (parabolic) velocity: $v^2_p = 2K_{\oplus☾}/r_{st}$ (3)

Hyperbolic excess velocity: $v^2_\infty = U^2_\oplus + V^2_1 - 2U_\oplus V_1\cos\beta$ (4)

Orbit canting velocity requirement: $(\Delta v_i)^2 = 4U^2_\oplus \sin^2 \frac{1}{2} i$ (5)

Angle between hyperbola asymptote and heliocentric departure angle: $\sin\gamma = U_\oplus \sin\beta/v_\infty$ (6)

Hyperbolic excess error: $\Delta v_\infty = v_P\,\Delta v_P/v_\infty$ (7)

Change in heliocentric departure velocity: $\Delta V_1 = V_1[1 - \cos(\Delta\beta)]$ (8)

Change in heliocentric departure angle:

$$\Delta\beta = \frac{2\left(1 + \frac{v^2_\infty}{K/r_p}\right)}{V_1 v_\infty \sec^2\phi}\,\Delta v_P \quad (9)$$

An introduction to space navigation

At present, celestial navigation appears to be a good candidate for the difficult job of guiding vehicles in interplanetary space

By Manuel Fernandez

MINNEAPOLIS-HONEYWELL REGULATOR CO., ST. PETERSBURG, FLA.

WE ARE at the brink of the "Space Age"—an era in which man's dreams of personally exploring the regions outside the Earth's atmosphere will become reality. Before those dreams come true, however, we must solve many propulsion, structures, human factors, guidance, and reliability problems in devising spaceships. Equally important, we must learn how to navigate in space within the limits of our technology.

What must we know to navigate in space? We can define space navigation as the problem of establishing a vehicle's position in the solar system. Space navigation, then, is only half the problem of guidance, the other half being steering, which involves comparing an ideal with an actual trajectory.

In this brief review, we will disregard problems of steering and deal primarily with the problem of navigation far removed from any body in the solar system. We will assume, that is, that the navigational problem of Earth departure can be handled by radio or inertial guidance systems similar to those used in today's rockets and that landing on a planet presents a very difficult special problem.

Celestial Navigation for Space

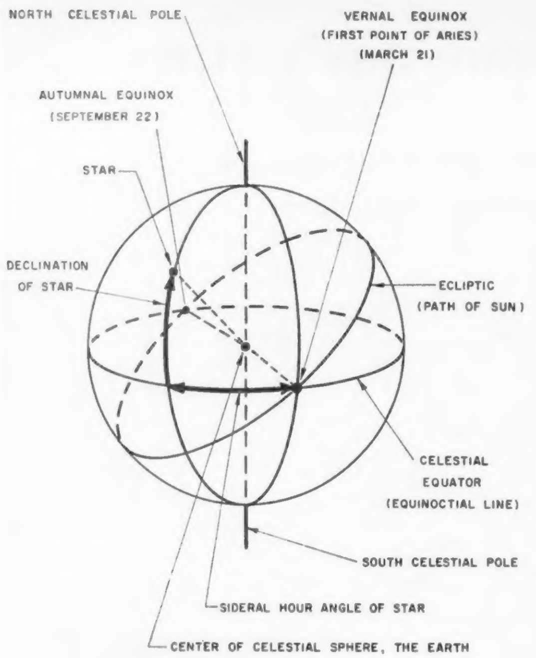
At the present time, celestial navigation appears a good candidate for space. Radio and dead-reckoning techniques have obvious shortcomings. Inertial navigation systems, which rely on acceleration measurements, have a disadvantage in that compensation must be provided for mass attraction. They are also inherently unstable if this compensation is not monitored by an external reference. (Furthermore, inertial acceleration-measuring system errors are no longer bounded by Schuler oscillations when the sum of radial acceleration and centrifugal acceleration equals or exceeds the mass attraction force per unit mass.) Although pure inertial acceleration-measuring systems are not directly applicable to space navigation, they can be used to provide short-time extrapolation between fixes and to furnish a gyro-stabilized platform on which apparatus for sighting stars and planets can be mounted.

We can approach the problem of space navigation with celestial fixes through comparable terrestrial navigation.

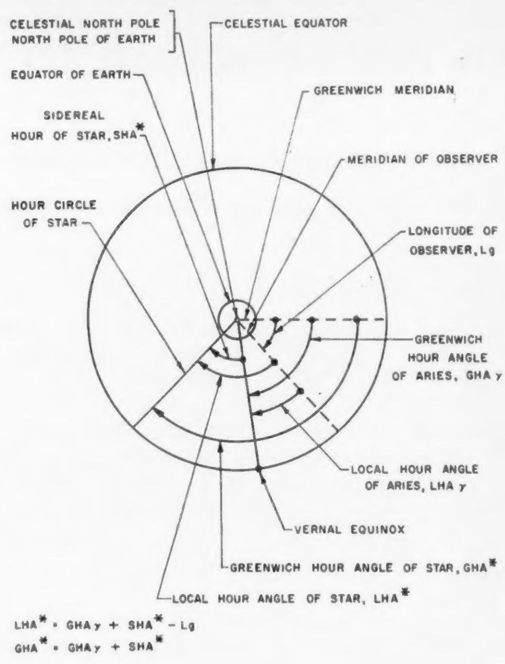
The use of stars to obtain a position fix is best understood by means of the hypothetical "celestial sphere" on which the stars (for practical purposes at infinity, viz., radius of sphere), except the sun,

Manuel Fernandez is senior development engineer in the systems section of Minneapolis-Honeywell's Inertial Guidance Center at St. Petersburg. After graduating from Georgia Tech in 1952 with a B.S. in electrical engineering, he entered the Air Force, spending his first two years at MIT, where he completed the Weapons Systems Engineering Course and was awarded an M.S. degree. For the next three years, he was project officer in the Air Force ARDC Inertial Section at Eglin AFB, where he helped conduct engineering evaluation flight tests of the K-Doppler bomb navigation system and the SIBS (stellar inertial bombing system). He also helped develop the AFAC Inertial Systems Flight Test Ranges and the required data reduction techniques. Since joining Honeywell in 1957, he has been engaged in the development of inertial guidance systems.

The Celestial Sphere



Local Hour Angle of a Star



have fixed positions and the Earth is the center, as shown above left. The equator and polar axis of the celestial sphere are parallel to Earth counterparts, and the sphere itself is nonrotating with respect to inertial space—therefore, to an observer on the Earth, apparently rotating at minus the Earth's daily rate.

Coordinates Analagous to Earth's

The coordinate system of the celestial sphere is roughly analagous to the Earth's latitude and longitude system. But the sphere's coordinates are called, respectively, declination and hour angle. The reference hour-angle great circle (hour circle) is taken as the Vernal Equinox (First Point of Aries), or the point corresponding to the location of the sun when it crosses the Earth's equator from the south to north (occurring about March 21).

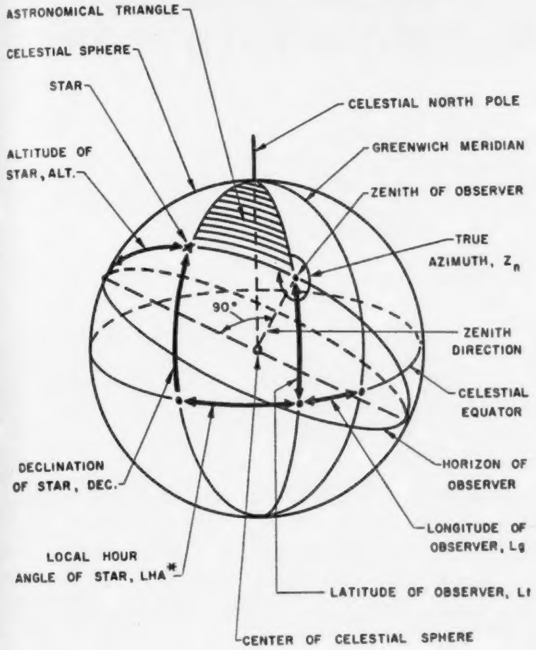
Star tables show the following information for each star (the Greenwich Hour Angle of the First Point of Aries is also tabulated as a function of the date and time of day in Greenwich Central Time): Number (corresponding to diagram), name, magnitude (relative brightness), sidereal hour angle, and declination. Then, to locate the point on the Earth directly underneath a star at any given time, you follow this operation: (1) Find the latitude of the star (which is equal to its declination); and (2) find the longitude of the star (which is termed the Greenwich Hour Angle of the star). The Greenwich Hour Angle of the star is calculated as shown in the figure above right. The rest of the problem is just spherical trigonometry. The figure top left on the opposite page shows the astronomical triangle.

The astronomical triangle introduces two new terms that need defining. The zenith of the observer is the point on the celestial sphere directly above the observer. The altitude of the star is the angle from the horizon of the observer (the plane perpendicular to the zenith direction) to the star.

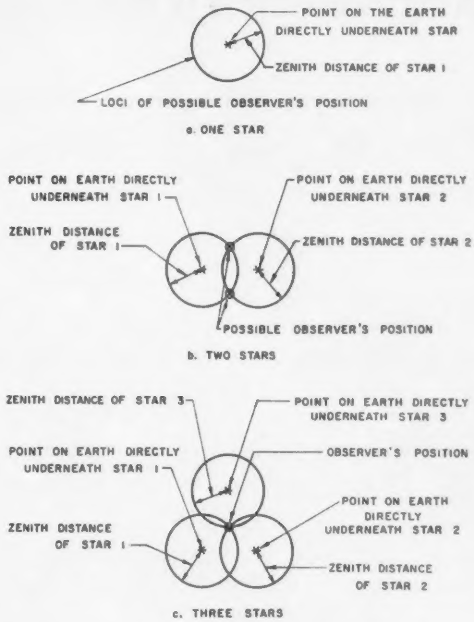
The following steps permit a position fix by sighting at stars:

1. Identify a visible star.
2. Find the altitude of the star; a horizontal Earth reference is required for this operation.
3. From star tables, find the declination and Sidereal Hour Angle of the star.
4. Knowing the date and time of day, find the Greenwich Hour Angle of Aries from star tables.
5. Find Greenwich Hour Angle of star from the following equation (see figure above right) $\mathrm{GHA}^* = \mathrm{GHA}_\gamma + \mathrm{SHA}^*$.
6. Knowing the declination of the star and the

The Astronomical Triangle

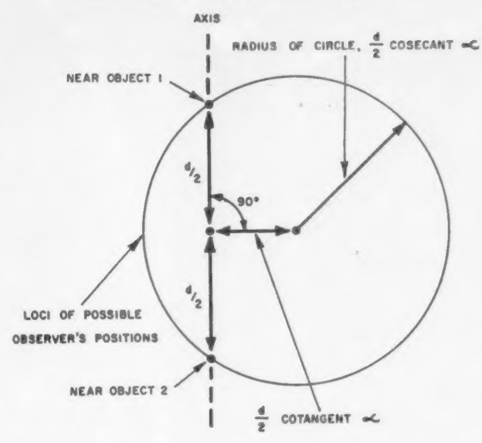


Solving for Position with Celestial Navigation



NOTE: The circles will not be in the same plane.

Sightings in Space Navigation



NOTE: The surface of possible observer positions is generated by rotating the loci about the axis.

Greenwich Hour Angle of the star, the point on the Earth directly underneath the star may be found. Declination of the star is latitude, and Greenwich Hour Angle of the star at this point is longitude.

7. The location of the observer is at a zenith distance equal to 90 deg minus (altitude of star) from the point on the Earth directly underneath the star.

Locate Observer's Position

These seven steps locate the observer's position somewhere on a known circle of positions, as indicated in part a of the illustration top right on this page. In general, three stars are required for a celestial position fix, as indicated in part c of the same figure. However, there is a special case where two stars have only one intersection, allowing no ambiguity of the observer's position. Also, if sufficient information is available, it is possible by using two stars to circumvent the ambiguity of the observer's position. (For example, the two possible positions of the observer may be thousands of miles apart and his actual position may be known to within a few hundred miles.)

In summary, then, this information and equipment must be available to effect a celestial position fix: Two or three visible and identifiable stars, apparatus for sighting stars, horizontal (or vertical) Earth reference, star tables, time (Greenwich Central Time), date, and computational means.

It is obvious that celestial fixes also can be made by sighting on the moon, planets, and the sun, as the declination and Green- (CONTINUED ON PAGE 76)

Rocket astronomy—Window into space

Soaring above the denser atmosphere, which blocks all but the visible spectrum and nearby portions of the ultraviolet and infrared, rockets with "photo-counter telescopes" show a new panorama of the heavens

By Herbert Friedman

U.S. NAVAL RESEARCH LABORATORY, WASHINGTON, D.C.

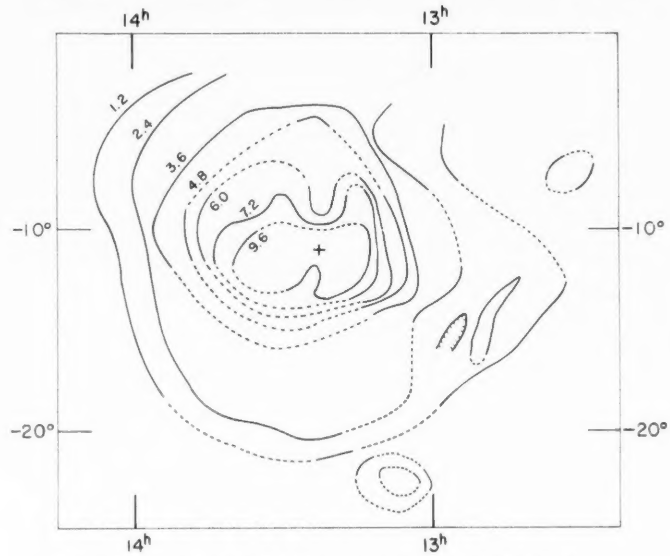
Herbert Friedman is long-time head of the NRL Electron Optics Branch. Actively engaged in upper atmosphere rocket research since 1949, particularly in the field of solar-terrestrial relationships, he was in charge of NRL's solar flare rocket experiments at San Nicolas Island, played an active role in the instrumentation of Vanguard, and was a member of the working group on internal instrumentation for the IGY Technical Panel on Earth Satellites. Dr. Friedman and other researchers of NRL presented papers on the first successful efforts in rocket astronomy to the American Astronomical Society last June.

THE UNIVERSE is filled with electromagnetic radiation ranging from long radio waves at one extreme to very short wavelength X-rays and cosmic rays at the other. But from the ground we see space through two narrow windows. The first encompasses the rainbow colors of the visible spectrum and nearby portions of the ultraviolet and infrared. The second window lies in the radio spectrum between wavelengths of 1 cm and about 40 m. At all other wavelengths the air above us is black, ultraviolet being absorbed by gases and longer wavelength radio emissions by the ionosphere.

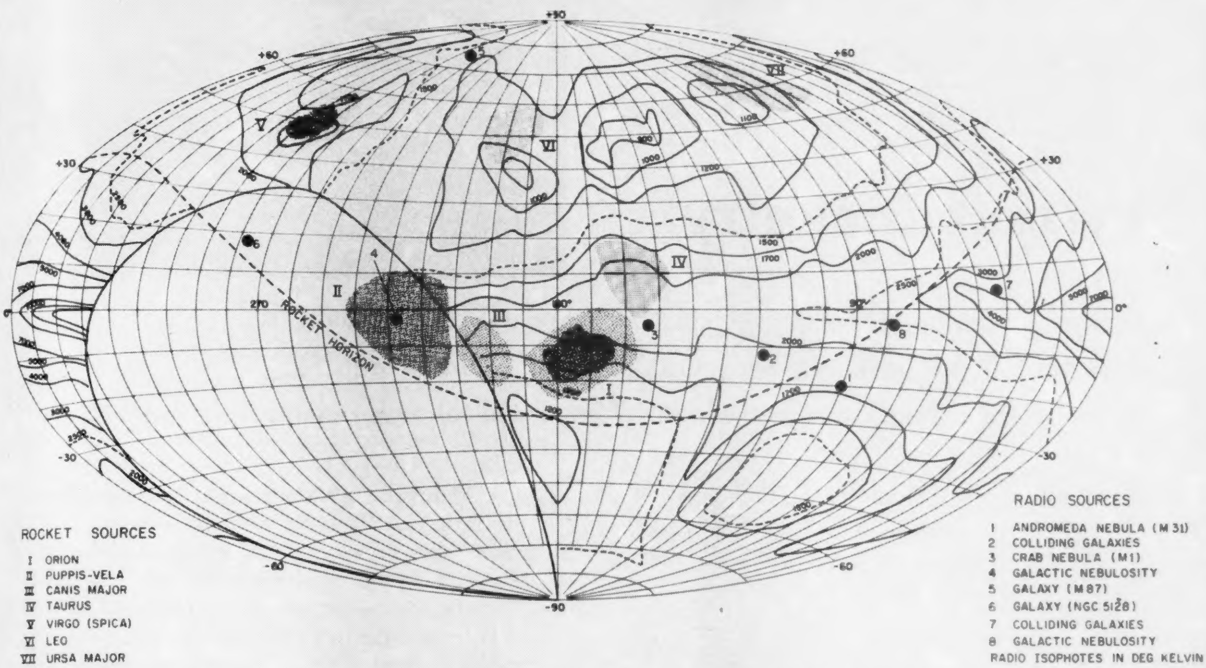
For most of history, consequently, our astronomical sight was limited to the optical window from 4000 A to 8000 A. By analogy with the piano keyboard, the visible range represents only one octave, whereas the full range of starlight would cover ten full keyboards.

Then, about 25 years ago, Jansky discovered cosmic radio waves,

Contour of Isophotes of Nebula Around the Hot Star Spica



Note: Values of surface brightness are in units of 10^{-4} erg/cm²/sec.



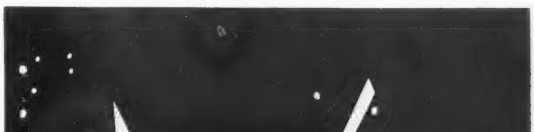
Radio (300 mc) and Ultraviolet (1300A) Map of the Sky in Galactic Coordinates

and opened our second window into space. Radio telescopes now scan the skies from observatories all over the world. Large aerial antennae substitute for optical telescopes. Radio waves have been observed from the sun and moon, our galaxy, as well as from distant galaxies. In its brief history, radio astronomy has already expanded our knowledge of the universe as much as previous centuries of optical astronomy.

Now we have a third window into space, for rockets and satellites can make astronomical observations by the ultraviolet which is masked to our eyes by the atmosphere.

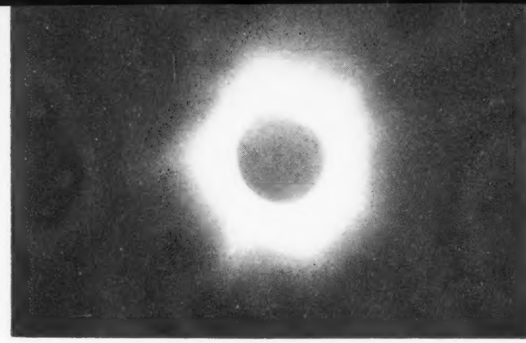
The first successful efforts to take a new look at the universe by means of rocket astronomy were described to the American Astronomical Society in June, 1958. In far ultraviolet—light that can only be seen from heights greater than 60 miles above the ground—our galaxy appeared to be filled with extended gas clouds. If we could see at a wavelength of 1300 A, two octaves higher than the frequency of visible green light, these gas clouds would be the brightest features of the sky, and stars embedded in them would barely be detectable.

The illustration at the right depicts the simple technique employed in our first successful attempt at rocket astronomy. An Aerobee-Hi sounding rocket carried aloft a "telescope" composed of a bundle of $^1/_2$-in. long hypodermic needles placed in front of ultraviolet sensitized photon counters (Geiger counters sensitive to ultraviolet light). These needles give a field (CONTINUED ON PAGE 69)

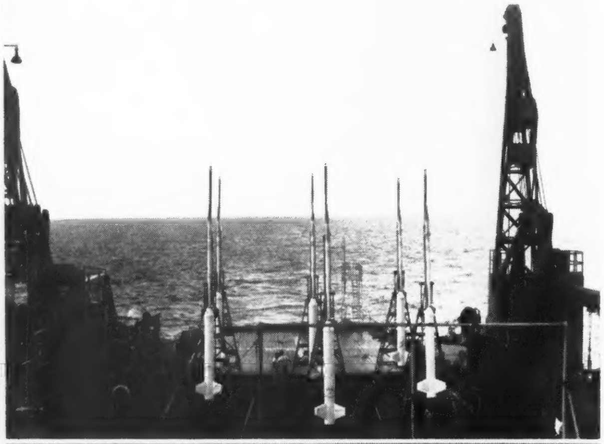


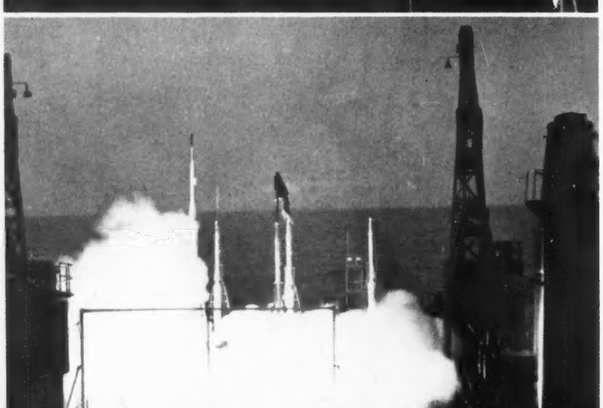
In the first successful attempt at rocket astronomy, an Aerobee-Hi carried aloft a "telescope" composed of a bundle of hypodermic needles to define the field of view and associated photon counters to measure ultraviolet radiation in the field.

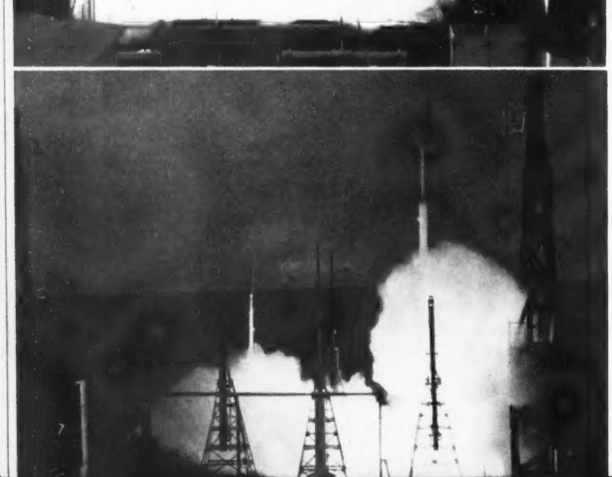
Instant rocketry



Rocket astronomy made an auspicious eclipse debut in Navy-IGY shipboard firings in South Seas Oct. 12, with valuable data obtained despite cloudy weather which defeated optical experiments







A TOTAL eclipse of the sun is the most spectacular sight that Nature offers in the heavens. For over 4000 years of recorded history, the occurrence of eclipses has been carefully documented, but modern scientific observation may be said to have begun about 100 years ago, with the introduction of photography, which in turn made possible photographic spectroscopy and its application to studies of the flash spectrum of the chromosphere.

The Oct. 12 eclipse marked the first attempt at rocket astronomy in an eclipse expedition, a technological advance perhaps comparable to the introduction of photography exactly a century ago. The importance of the rocket as a platform for astrophysical observations is that it opens up a view of the broad scale of all electromagnetic frequencies otherwise absorbed by the atmosphere, making it possible, for example, to observe directly the ionizing radiations responsible for ionospheric phenomena.

The eclipse of Oct. 12 began at sunrise on the equator near New Guinea and raced across the Pacific Ocean for about 8500 miles to the coast of Chile near Valparaiso, where it left the Earth at sunset. It took 3 hr and 10 min to cross the Pacific at an average speed of 2670 mph. In all its long path, which at its maximum breadth was only 150 miles, the eclipse managed to miss all the large South Pacific islands and could be observed on land from only a small number of tiny coral atolls. A British and New Zealand expedition made its base on Atafu. The Danger Islands, chosen by the American group, are a group of three small islets, Pukapuka, Motu Ko, and Motu Katava. These comprise 1250 acres and a few sand banks around a barrier reef that encloses a lagoon about 5 miles long

To obtain data on various phases of the eclipse, six shots were scheduled within a 40-min period. Top photo shows the six Nike-ASP's ready for launching on well-deck. Second and third photos show firing of No. 2 and No. 4 rockets, only 10 min apart.

and 2 to 3 miles wide. The group of American astronomers based their camp on Motu Katava. A third expedition of Japanese scientists sailed to Suwarrow Island, while a Swiss party made observations on the coast of Chile.

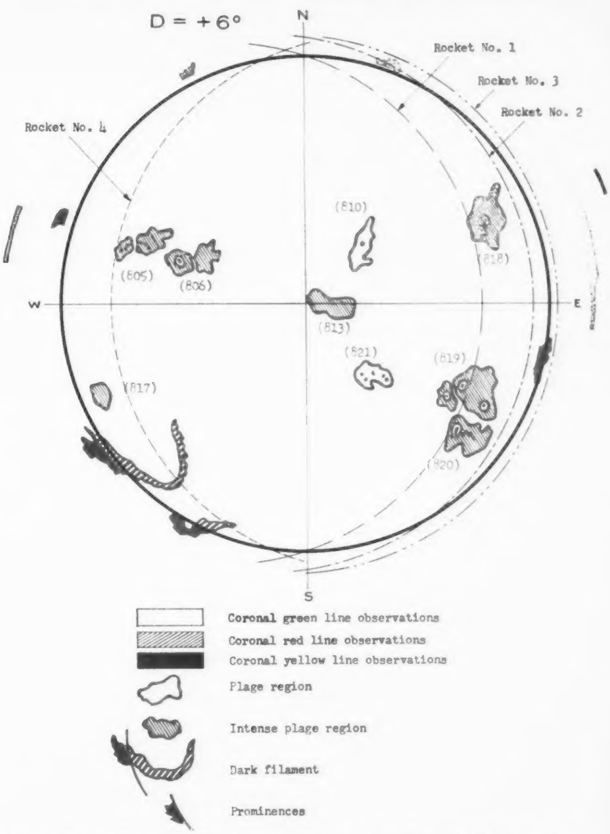
The American scientific parties were divided between a shipboard team to handle the rocket experiment and five groups of experimenters based on the island. Herbert Friedman led a group of 10 scientists and engineers from the Naval Research Lab, with Talbot A. Chubb, John C. Lindsay, and Robert E. Kreplin responsible for various phases of the rocket astronomy program. In the mounting and arming of the rockets, this group was assisted by Robert E. Cox and two engineers from Cooper Development Corp., Monrovia, Calif.

The NRL rocket experiment utilized the helicopter deck of the USS Point Defiance, LSD 31, under the command of Capt. Edwin H. Woodhead (USN). This remarkable ship was a floating hotel, machine shop, and laboratory for the experiments. The ship, almost the length of two football fields, has a beam of 84 ft, displaces 13,000 tons and can make a speed of 25 knots. Its unique feature is a well-deck running almost the full length of the ship. By dropping the tailgate and ballasting down, the well-deck can be flooded to a depth of 10 ft., so that it is possible to embark a large number of fully loaded landing craft of amphibious vehicles of various sizes and types. The ship is equipped with all the facilities necessary to serve as a drydock and repair shop for landing craft and vechicles. Its two cranes, each capable of lifting 50 tons, were more than adequate for handling the mounting of rockets at sea.

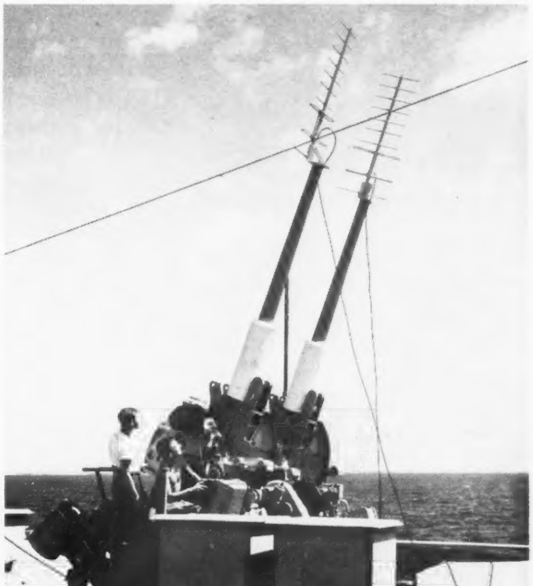
How We See the Sun

We see the sun as a simple yellow disk whose surface is clear except for occasional dark blemishes in the form of sun spots. Eclipse observations long ago revealed the faint tenuous coronal atmosphere extending out millions of miles beyond the rim of the solar disk and the red chromospheric prominences arching tens of thousands of miles above the photosphere. When the disk itself is observed with the aid of color filter devices which pass narrow wavelength bands corresponding to the emissions of excited hydrogen, helium, or calcium atoms, the solar surface takes on a mottled, turbulent appearance resembling an orange peel. Observed in these monochromatic wavelengths, the sun presents a continuously varying picture. Solar weather is a dynamic complex of plages, spicules, prominences, flares, coronal hot spots, and varying magnetic fields associated with sunspots. (CONTINUED ON PAGE 82)

The Solar Disk for October 12, 1958



Dashed lines show positions of occulting edge of moon projected on sun's disk at various phases of the eclipse.



Telemetry antennas were emplaced in the nozzles of pairs of 3-in. guns which could be turned to follow the rockets' flight.

Mars—A world for exploration

Target for balloon observations and interplanetary probes, the red planet presents mysteries of physical form and life, answers to which may enhance our understanding of the earth

By Clyde W. Tombaugh

NEW MEXICO COLLEGE OF AGRICULTURE AND MECHANIC ARTS, STATE COLLEGE, N.M.

Clyde W. Tombaugh, who discovered the planet Pluto, is one of the country's best-known astronomers. As a young man, he built his own telescopes. Drawings of Mars and Jupiter which he made with a 9-in. telescope led to his employment at Lowell Observatory—from which his sighting of Pluto was made in 1930—and thence to a scholarship at the Univ. of Kansas, where he received an M.S. in Astronomy in 1939. Since then, he has been an astronomer and teacher at Arizona State College, Univ. of California at Los Angeles, White Sands Proving Ground and, currently, New Mexico A&M. At White Sands, he contributed to the application of planetary photography to high-altitude rocket tracking, and from his experience there he devised a scheme Earth orbits, a project now in progress. Prof. Tombaugh is an ARS Fellow.

A CENTURY and a half ago, Herschel observed the seasonal changes in the white polar caps of Mars with his homemade telescopes, which were the most powerful of his time. He also saw bluish dark markings (maria) distributed over the reddish disk, and thought them seas of water surrounded by continents of ruddy-soiled land.

For nearly a century after, it was generally believed that Mars was a world much like the Earth, except that its diameter was only half Earth's and its year nearly twice as long.

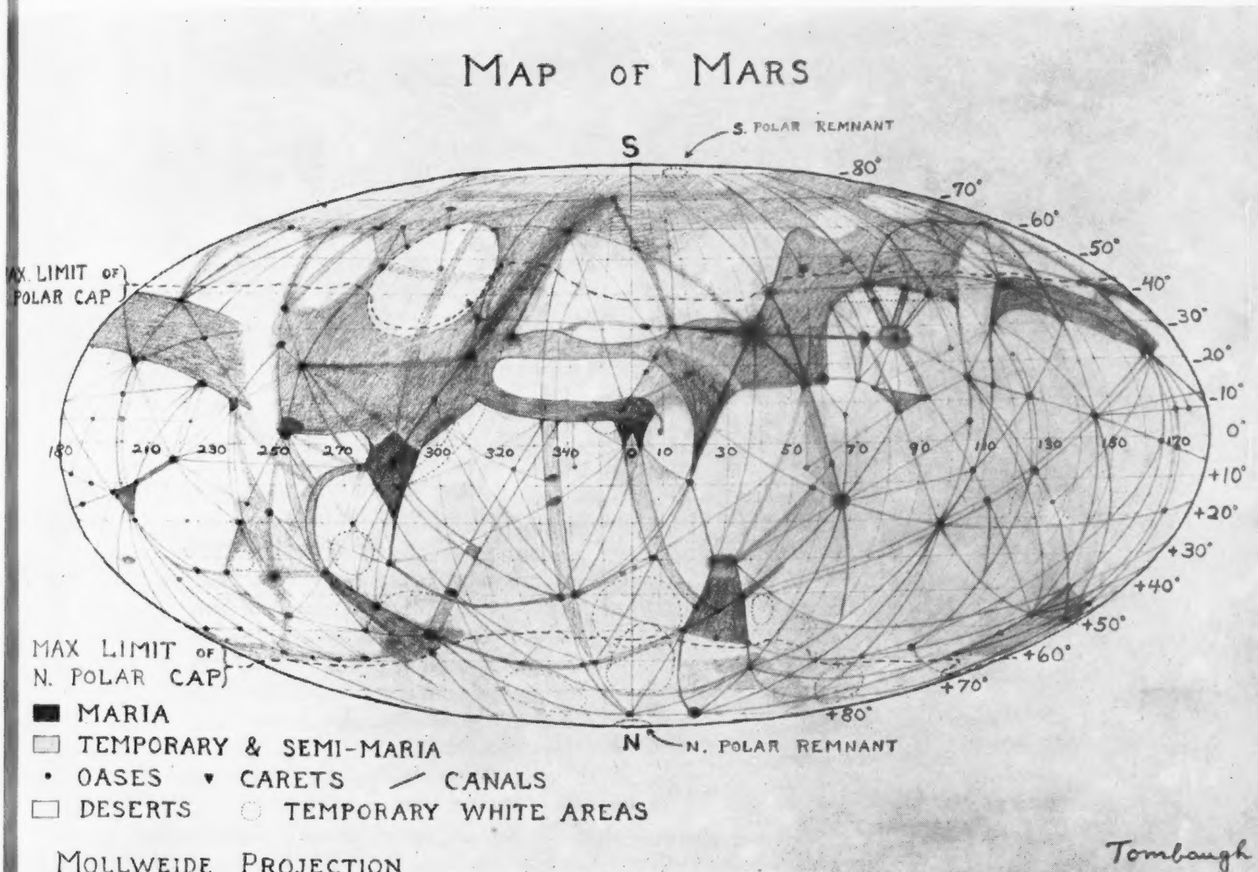
In 1877, Schiaparelli, an Italian astronomer, discovered a curious network of long dark lines, which he regarded as channels, connecting the dark areas. They were mistranslated as canals. Schiaparelli continued to observe the planet carefully and assiduously, and he noted that the dark areas underwent remarkable changes in color. This seemed unbecoming for seas. Finally, he ascribed this behavior to changing depth of water in very shallow seas. Indeed, some of them seemed to dry up altogether during certain seasons.

Astronomers were never successful in seeing the virtual image of the sun reflected from the maria, which should have been possible from bodies of water. When several astronomers in 1892 saw narrow, darker streaks within the dark areas, and Percival Lowell observed that the required change in water depth to produce the changes in color would involve unthinkable quantities of water to be evaporated, it became evident that Mars was a world without an ocean.

Lowell Studied Mars

In 1894, Lowell erected an observatory at Flagstaff, Ariz., where, until his death in 1916, he and his associates studied Mars diligently with a fine 24-in. refractor. The curious behavior of the canals and the small, round, dark dots (known as oases) especially interested Dr. Lowell. He concluded that the canals were long, narrow strips of irrigated vegetation bordering artificial water courses which transported water from the melting polar snows. The oases he thought canal junctions—probably the cities of Mars.

Lowell proclaimed the canal system a vast worldwide engineering works of a highly intelligent race of beings slowly dying of thirst. He believed that the dark maria of vege- (CONTINUED ON PAGE 86)



INDEX TO MAP OF MARS

	Longitude	Latitude
Deserts		
Aeria	305°	N 10°
Elysium	215	N 20
Hellas	285	S 45
Maria		
Acidalium	32°	N 41°
Dawe's Forked Bay	0	S 7
Hellespontus Depressio	320	S 45
Margaritifer Sinus	22	S 10
Sabaeus Sinus	335	S 8
Syrtis Major	284	N 5
Trivium Charontis	200	N 15
Oases		
Nilus Lucus	278°	N 31°
Oxia Palus	19	N 10
Pseboas Lucus	296	N 39
Solis Lacus	88	S 27

Canals		
Astusapes	287°	N 26°
Cantabras	10	N 5
Djihoun (double)	1	N 28
Indus	23	N 20
Nilotis	281	N 25
Oxus	13	N 20
The great desert tetrahedral vertex areas		
Tempe-Tharsis-Arcadia	95°	N 20°
Elysium	215	N 20
Arabia-Eden	335	N 25
South Polar Remnant	40	S 84
The great maria tetrahedral faces		
Mare Erythraeum	50°	S 25°
Sirenum-Cimmerium	170	S 30
Tyrrhenum-Syrtis Major-Hellespontus	290	S 15
The maria faces of the lesser tetrahedron		
Mare Acidalium	35°	N 40°
Propontis	170	N 50
Wedge of Casius	265	N 45

NOTE: Coordinates give approximate centers or midpoints.

Weather reconnaissance by satellites

Our newest and most far-ranging instrument promises to provide continuity in time and space to synoptic meteorology for the first time

By S. M. Greenfield and W. W. Kellogg

THE RAND CORP., SANTA MONICA, CALIF.

Greenfield Kellogg

Stanley M. Greenfield is a physical scientist in Rand's geophysics group. He received a B.S. in meteorology in 1950 from NYU's College of Engineering, where he worked on a project to develop a constant-altitude balloon, and joined Rand immediately on graduating. At Rand he has been active in the fields of meteorology, upper-atmosphere physics, reconnaissance systems, infrared radiation, radioactive fallout and satellites, while also doing graduate work in physics at UCLA.

William W. Kellogg, head of Rand's geophysics group, received a degree in physics from Yale in 1939, and a Ph.D. in meteorology from UCLA in 1949. His background includes five years with the Air Force as an instructor in meteorology, weather officer and project officer for the development of weather equipment, and two years as an assistant professor at UCLA's Institute of Geophysics. At Rand, which he joined in 1947, he has worked on meteorology, the upper atmosphere and space flight. He is a member of the Technical Panel for the IGY Earth Satellite Program and of the IGY Rocket and Satellite Research Panel.

WHILE a worldwide weather data collection network has been in operation for some time, this network provides very limited data on certain large areas, such as the oceans and polar regions. The only means presently available for filling the gaps in such data is weather reconnaissance by aircraft and ships, and, since such reconnaissance must of necessity be spatially spotty, the program lacks the one quality of observation most necessary to synoptic meteorology—continuity in time and space.

Our newest and most far-ranging instrument, the satellite, promises to supply this continuity for the first time. A weather reconnaissance satellite has been planned, and considearble thought has been given to what it might measure, and how its measurements would fit into the present weather system.

Initially, useful weather observation from a satellite would be mainly optical, by "looking down" on the visible manifestations of weather. The first attempt to do this is planned for the IGY satellite program. William Stroud and his associates at the Army Signal Engineering Laboratories have already developed a simple scanning system for the Vanguard satellite.

Will Initially Be Qualitative Data

Simply observing the weather through the "eye" of a high-altitude robot causes almost all *quantitative* measurements usually associated with synoptic meteorology to fall by the wayside. Optically derived data would make impossible more than an intelligent guess at values of temperature, pressure, humidity and the remaining conventional meteorological parameters. Moreover, using this type of data as the sole source on which to base a weather analysis is almost completely foreign to the normal experience of the synoptic meteorologist. The basic limitation of weather satellites, then, is the degree to which meteorologists can apply what will initially be *qualitative* information to the science of synoptic weather analysis.

Clouds, being the objects most discernible from extreme altitudes, become the important target for satellite observation, and must be utilized to the utmost in forming a synoptic picture. From clouds alone, it would be impossible to tell everything about the current synoptic situation. But an accurate cloud analysis can produce surprisingly good results in areas where no informa-

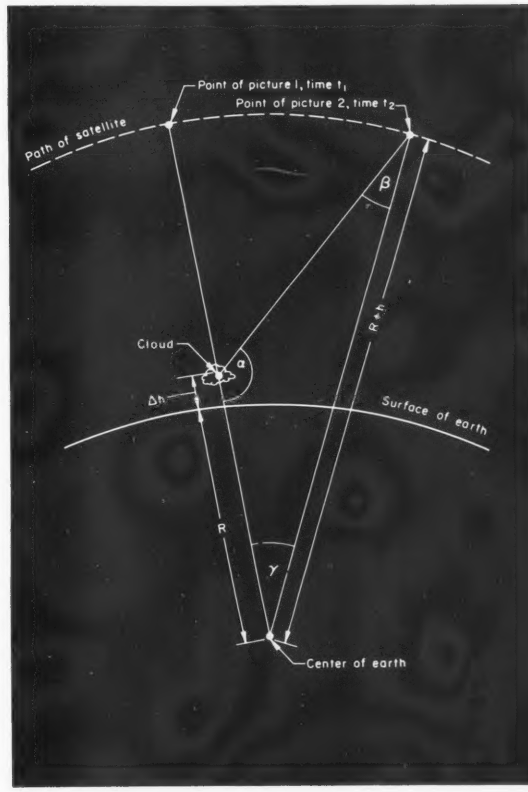
tion is available, and, where there is good synoptic data on the earth's surface, satellite cloud observations should give a continuity not presently available.

If cloud observations will initially be the major output from a weather reconnaissance satellite, it is logical to ask: Is there any difficulty in seeing and identifying clouds from satellite altitudes? And what synoptic data can be obtained from such observations?

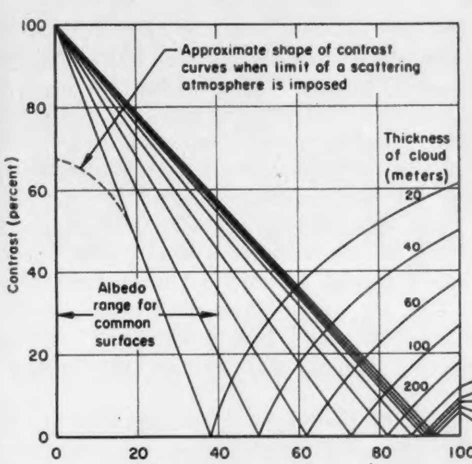
Our studies indicate clouds can be seen and identified adequately from satellites. The graph shown below describes cloud contrast in terms of Hewson's work on diffuse reflection coefficients for clouds of various thickness. From a knowledge of background albedos (less than 0.4 for most surfaces), it is possible to show that, except for snow and low solar elevations over a water surface, the contrast between clouds and background will be greater than 40 per cent. Most television or photographic equipment expected for satellites can work from a contrast greater than 40 per cent.

Contrast and ground resolution are intimately related. In cloud photography, useful information can be obtained with quite poor resolution. For example, gross cloud cover can certainly be obtained with the ability to resolve ground dimensions of the order of one mile or greater. To identify cloud types, it is necessary to resolve ground dimensions of the order of 500 to (CONTINUED ON PAGE 77)

Conditions for Determining Cloud Height

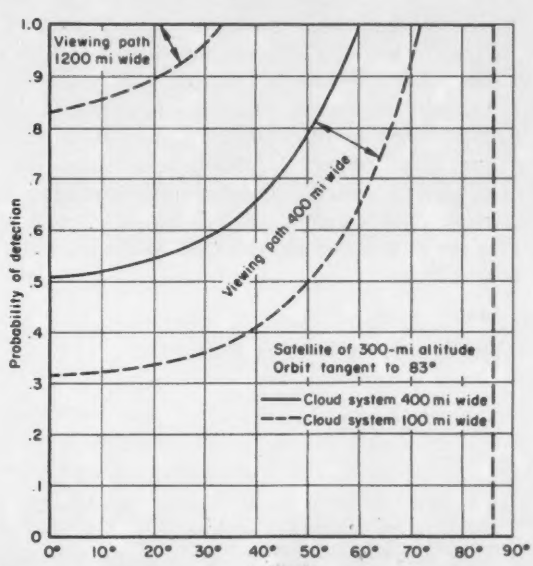


Cloud Contrast



Note: Contrast is defined as brightness (albedo) of the brightest thing viewed (either object or background) minus brightness of darkest thing viewed, divided by albedo of the brightest.

Probability of Detecting Clouds on a Given Day



The new and the old, Col. John P. Stapp, ARS president-elect, poses with outgoing president George P. Sutton (right) just prior to banquet.

Stapp heads ARS for 1959

Seifert elected Vice-President. . .Nine new Directors named, bringing Board up to 15 members. . .Record attendance marks 13th Annual Meeting

By Irwin Hersey

THE fact that the 13th Annual ARS Meeting in New York Nov. 17–21 was the biggest and most successful in the Society's 28-year history came as no surprise to anyone, since advance registration had indicated quite early that a new attendance record would be set. What was unexpected, however, was the actual figure—some 5430 persons, or roughly 1000 more than had been anticipated by even the most optimistic members of the headquarters staff.

Attendees From Foreign Countries

The members and guests who jammed the Hotel Statler during the five-day meeting came from every state in the union and seven foreign countries. A last-minute guest was Leslie R. Shepherd, Chairman of the Council of the British Interplanetary Society.

They came to participate in the many technical sessions; to meet the Society's new officers and directors; to honor their fellow engineers and scientists who were presented with awards at the Honors Night Dinner; to wander through what was unquestionably the most impressive Astronautical Exposition to date; to hear major addresses by top figures in the field of rocketry and astronautics; and, perhaps most important of all, to get together in the long bull sessions over beer and skittles which make meetings of this kind so important.

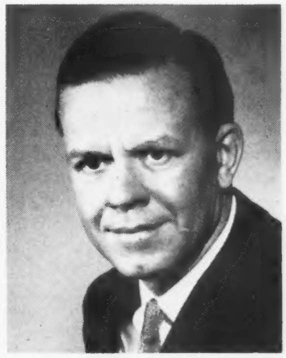
Heading the Society for the coming year will be Col. John P. Stapp, Chief of the Aero Medical Laboratory, Wright Air Development Center, Wright-Patterson AFB, as president, and Howard S. Seifert of Space Technology Laboratories, as vice-president.

Expansion of the Board of Directors from nine to 15 members meant that nine new directors, rather than three, were elected this year. Named to three-year terms were: William H. Pickering, director, Jet Propulsion Laboratory; James R. Dempsey, vice-president, Convair Div. of General Dynamics; Lt. Col. David G. Simons, assistant chief, Aero Medical Field Laboratory, Holloman AFB; John L. Sloop,

1959 ARS Officers and Board Members

OFFICERS

Col. John P. Stapp
President

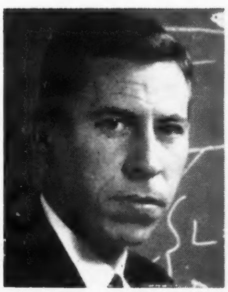


Howard S. Seifert
Vice-President

Robert M. Lawrence
Treasurer

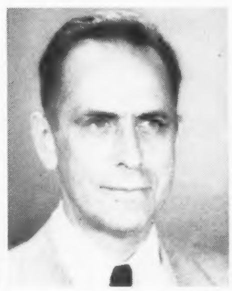
DIRECTORS

J. R. Dempsey



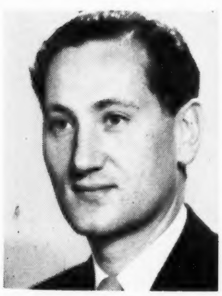
A. J. Eggers Jr.

Krafft Ehricke

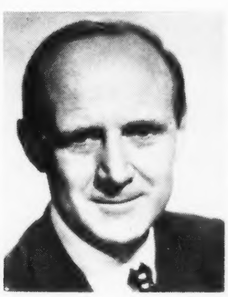


S. K. Hoffman

J. P. Layton



A. K. Oppenheim



W. H. Pickering

Simon Ramo

H. W. Ritchey

W. L. Rogers

Lt. Col. D. G. Simons

John Sloop

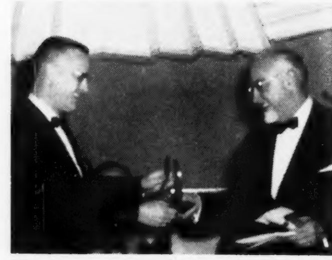
Martin Summerfield

Wernher von Braun

Maurice Zucrow

R. B. Canright of ARPA receives Goddard Award from Mrs. Robert H. Goddard.

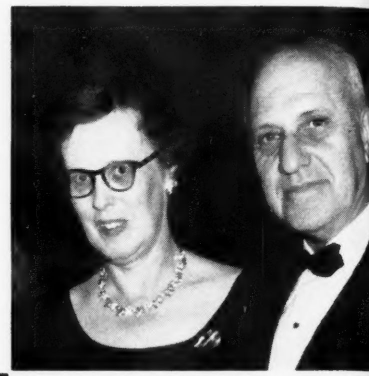
Maj. Gen. H. N. Toftoy of Aberdeen Proving Grounds accepts James H. Wyld Award from Mrs. Wyld.



Homer E. Newell Jr. of NASA receives G. Edward Pendray Award from Dr. Pendray.

C. N. Hickman presents Hickman Award to Barnet Adelman of Space Technology Labs.

Mrs. Iven C. Kincheloe Jr. accepts ARS Astronautics Award from Andrew G. Haley in behalf of her late husband.



Mrs. Robert H. Goddard poses with Harry Guggenheim.

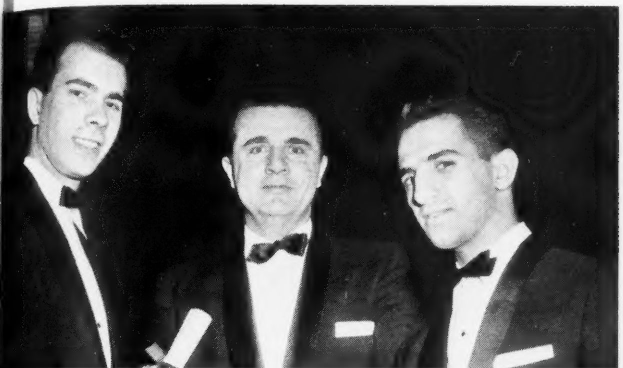
Left to right, Rear Adm. & Mrs. John E. Clark of ARPA, Mr. & Mrs. Kurt Stehling of NRL and Homer E. Newell.

Mrs. Iven Kincheloe, Irving J. Minett of Chrysler Corp. and Sam Hoffman of Rocketdyne.

NASA Lewis Research Center; and Antoni K. Oppenheim, associate professor of aeronautical sciences, Univ. of California at Berkeley.

Samuel K. Hoffman, vice-president of North American Aviation and general manager of its Rocketdyne Div., and J. Preston Layton, research engineer, Univ. of California Livermore Radiation Laboratory, were elected to two-year terms, while Alfred J. Eggers Jr. of NASA Ames Research Center and William L. Rogers, vice-president- Azusa operations, Aerojet-General, were named to one-year terms.

President-elect Stapp presents outgoing president Sutton with plaque.



Former Fenn College students Thomas W. Godwin Jr. (left) and Carl F. Lorenzo (right), winners of ARS-Chrysler Corp. student award, flank Irving J. Minett, Chrysler Corp. group executive–defense, who presented the award.

At right, Frederick H. Reardon of Princeton Univ. (left), winner of ARS-Thiokol Chemical Corp. Award for advanced study in rocket science, poses with Lt. Gen. James M. Gavin (center), banquet speaker, and H. R. Ferguson, Thiokol executive vice-president, who presented the award.

At left, staff powwow. ARS director of member relations Scott Bailey, ARS JOURNAL editor Martin Summerfield, ASTRONAUTICS editor Irwin Hersey lend an ear to some words of advice from Ed Pendray.

ARS executive secretary James J. Harford (center) and Gen. Gavin listen attentively to H. W. Ritchey of Thiokol.

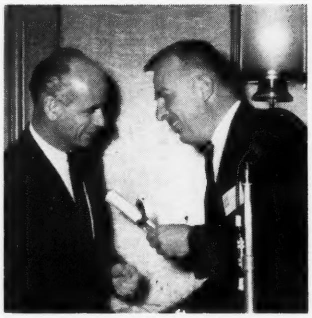
Left to right, C. Stark Draper of MIT, new ARS fellow member; Maurice J. Zucrow of Purdue Univ., and Gen. Toftoy.

Continuing as Board members are Krafft Ehricke, Convair-Astronautics; Simon Ramo, Thompson Ramo Wooldridge; Harold W. Ritchey, Thiokol Chemical Corp.; Martin Summerfield, Princeton Univ.; Wernher von Braun, ABMA; and Maurice J. Zucrow, Purdue Univ.

Robert M. Lawrence, Reaction Motors Div. of Thiokol, continues as treasurer, with James J. Harford as executive secretary, A. C. Slade as secretary and assistant treasurer, and Andrew G. Haley as general counsel.

Realignment of the ARS Technical Committee

Below left, part of the crowd of 175 students who attended Student Conference and listened attentively to Capt. Robert C. Truax lecture on steam rockets.



Left to right, Kurt Stehling presents fellow memberships to Robert A. Gross of Fairchild, C. Stark Draper of MIT, Ernst Stuhlinger of ABMA, and R. D. Gompertz of GE.

Dick Holbrook of ARPA discusses sealed cabins as session chairmen Eugene B. Konecci of Douglas and Brig. Gen. Don Flickinger check a point.

Jim Harford calls the roll at Section Delegates Luncheon.

Col. Stapp reads a note to NASA's Hugh Dryden, also a luncheon speaker.

Luncheon speakers Simon Ramo of Thompson Ramo Wooldridge and Roy Johnson of ARPA in action.

setup was announced at the meeting by outgoing president George P. Sutton. He explained that the field of rocketry and astronautics has grown so rapidly that the number of Technical Committees is being raised from nine to 22 in order to cover the entire field and permit more active participation by ARS members in a number of widely divergent areas.

The new committees, along with those chairmen already named, are: Non-Propulsive Power, Abe Zarem, Electro-Optical (CONTINUED ON PAGE 62)

Astronautical exposition highlights

Col. John P. Stapp, ARS president-elect, shies away from unique rocket firing engineered by Phil Hufford of Linde Co. in Hotel Statler lobby at opening of ARS Astronautical Exposition.

Interesting and unusual exhibits, many prepared especially for the show, kept the aisles crowded throughout the three-day exposition.

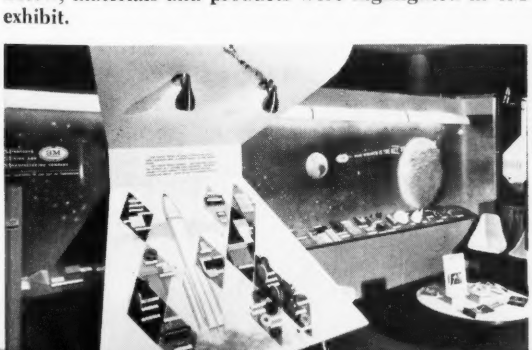
Aerojet's display featured models of missiles for which it produces rocket engines.

Polaris played starring role in impressive Lockheed display.

Missile heating, plumbing problems were spotlighted in Marman and Aeroquip exhibits.

Westinghouse display (below right) used visual and audio techniques to provide visitors with rundown on space flight problems.

Below, materials and products were highlighted in 3M exhibit.



The earth satellite orbit

Behind the glancing arc of the earth satellite lies a complex geometry and perturbing forces not yet entirely identified

By Major Ballard B. Small (USA)

ATLANTIC MISSILE RANGE, PATRICK AIR FORCE BASE, FLA.

Maj. Ballard Small is Chief of the ABMA Project Office at the Atlantic Missile Range, Patrick Air Force Base, Fla., responsible for proving ground support providing Army ballistic missiles there. He graduated from the Univ. of California in 1943, with specialization in physics and the geophysical sciences, and in 1953 received an M.A. in educational measurement from Columbia Univ. Teachers College. His experience in the Army was in combat arms before joining the Ordnance Corps. He has been at Patrick since 1954 and with ABMA since its formation in 1956, first as a project officer for the Redstone Missile and later as the Jupiter Project Officer.

THE ARTIFICIAL moons men have set revolving about our Earth seem to trace smooth and graceful arcs across the morning and twilight skies. The casual observer may therefore conclude that satellite paths are comfortably predictable through the laws of motion set down by Kepler. This is not so. The little moons do move under the basic laws of gravitational mechanics, but they are incidentally affected by a variety of influences, and their motions, although seen as smooth curves, are highly complex.

An analysis of the geometry and dynamics of near-Earth satellite orbits involves many more factors (some very imperfectly known) than those few coefficients in the Newtonian mechanics of a pure two-body system. For instance, the gravitational field through which these satellites pass is not really proportional to the square of the distance from the center of the Earth. It is also not distributed circularly, partly due to the ellipsoidal shape of the Earth, nor even elliptically, due to the nonhomogeneity of the distribution of the Earth's mass. Moreover, air density variations are not known theoretically, and change continuously in an unpredictable manner. Other factors as yet unknown may also affect satellite motion. Consequently, orbit prediction, involving the solution of a number of nonlinear differential equations of motion, demands quite a bit even of the super-intellect of a large computer.

Six Elements Describe Orbit

At least six values, called orbital elements, are required to describe the orbit and motion of an earth satellite. In planetary motions within the solar system, a heliocentric reference system is used, with the sun as the primary body and the plane of the ecliptic as the basic reference. For earth satellites, the Earth is considered the primary and the Earth's equatorial plane is taken as the reference. For this reason, orbital elements for earth satellites are sometimes called equatorial elements.

There are obviously two planes of principal interest in the satellite's orbit: The Earth's equatorial and the satellite's orbital plane. The first drawing on the opposite page shows these planes in a typical relationship. All orbital measurements are made in these two planes.

To begin with, it is assumed that all disturbing forces and perturbations are removed and that data are taken at the same arbitrary

starting point (epoch) in time, usually the moment when the satellite passes perigee. This may be *any* pass, and not necessarily the first. An example of epoch might be: 1958 February 1. 16528 decimal of days. It could just as well be set in Universal Time, Eastern Standard or in other ways.

The epoch may be defined more restrictively as the instant of osculation. "Osculation" refers to the fact that the so-called elliptical elements are considered "frozen" for that instant. "Elliptical" refers to theoretical values, i.e., disregarding all perturbations and anomalies. The osculating elements would therefore describe a theoretical elliptical orbit not influenced by geodetic anomalies or, at the given instant, other celestial bodies.

The six osculating orbital elements in the table below are required to establish orbital geometry and satellite motion. Five of these are equatorial elliptical elements, which define the space position of the satellite, and the sixth is a time-based element used to predict the satellite's location at any given time.

Velocities Not Basic Parameters

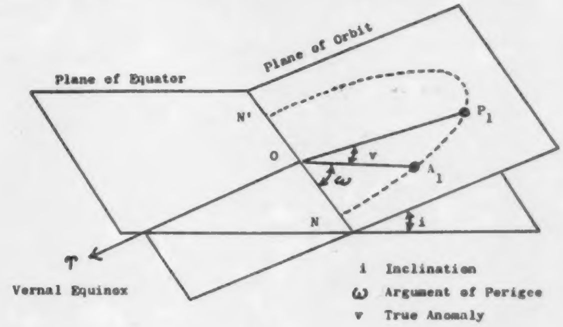
Satellite velocities are not elementary parameters because the osculating elliptical motion is harmonic and the velocities change constantly but periodically according to the laws of harmonic motion. The period of the satellite uniquely establishes the various velocities once elliptical elements are defined.

Knowing the osculating elements, the theoretical space position, and hence the direction and distance of the satellite from the fictitious center of the Earth, may be calculated. To obtain absolute positions, however, true kinematic elements must be used. These are generally developed through formulas that correct each of the un- (CONTINUED ON PAGE 46)

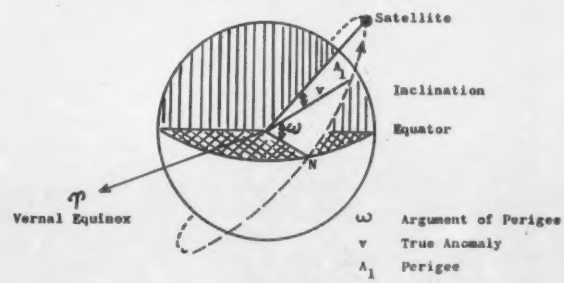
OSCULATING ORBITAL ELEMENTS

Inclination (i)	Sets orbital plane against equator
Right ascension of ascending node (Ω) or (α_Ω)	Sets orientation of the orbital plane in solar system
Argument of the perigee (ω)	Orients the orbit within orbital plane
Eccentricity (e)	Defines form of the orbit
Semimajor axis (a)	Defines size of the orbit
Time of perigee passage (τ)	Defines motion in the orbit

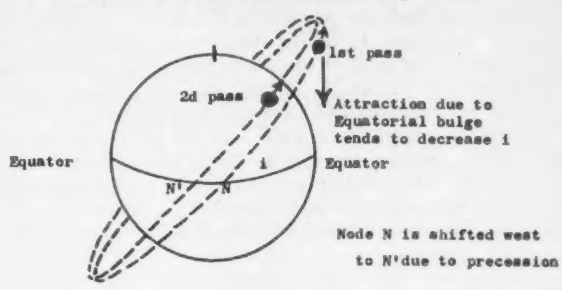
Equatorial Elements of Satellite Orbit



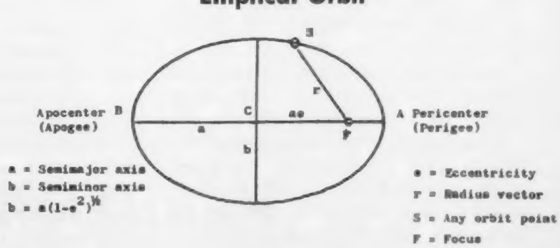
Elements of an Earth Satellite



Effect of Noncentral Gravity Field



Elliptical Orbit



Interplanetary Probes

(CONTINUED FROM PAGE 22)

maneuvers are required en route except for correction. This has two advantages. It simplifies the mechanism of instrumented probes, and it tends to reduce the over-all energy required by adding the individual energy requirements vectorially rather than arithmetically.

Thus, in order to minimize hyperbolic departure velocity (v_{vi}) it is necessary to find the right compromise between "fastness" of orbit (v_∞) and inclination of orbit (Δ_{vi}). *For hyperbolic encounter probes, this leads to relatively fast, moderately canted transfer orbits, unless the transfer is close to nodal.*

Fast orbits are also desirable to reduce as much as possible the distance between the probe and Earth at time of encounter. Closeness between the probe and Earth reduces radio-transmission power requirements.

If capture by the target planet is intended, there must be a shift toward slower (more nearly cotangential) transfer orbits, even at higher canting angles, to conserve energy during the capture maneuver.

We return now to the launching periods, which for the period 1959–67 are shown on the chart on page 21 with the nodal and apsidal lines of inner solar system planets. The dashed portions of the orbits are below the ecliptic. In the figure, the dark bars refer to Earth–Mars flights, the light bars to Earth–Venus flights. The blocks indicate position of Earth and target planet during the time period a launching of the probe may be considered. *In 1959 and 1967, transfer conditions to Venus are very favorable, permitting a nodal transfer.*

For Venus, a transfer orbit with transfer center angle near 180 deg is of interest because it provides a fairly large elongation of Venus from the Sun at time of encounter. Data transmission against a background of solar and solar-induced radio noise is then avoided and optical tracking is facilitated. With transfer center angles near 180 deg, shorter suitable launching periods are obtained for Venus than for Mars. By selecting a variety of transfer orbits to Mars—for example, ranging from negative departure angles (departure vector directed inside the Earth's orbit) to contangential departure and to departure at positive angles—one obtains a certain time period within which launchings to Mars are possible with adequate payload weight. This period is of the order of 6 to 12 weeks, depending on the flight performance of the vehicle.

Since the energy requirements for these transfer orbits vary, however, the payload capability of the individual missions varies correspondingly, being smallest at the beginning and the end of the launching period and reaching a maximum between. For the transfer to Venus, similar possibilities for obtaining an extended launching period exist by using transfer orbits having aphelion outside the Earth's orbit.

Comparatively favorable transfer conditions will exist for Mars in 1962 and November, 1964 (marked 65 on the chart), because of the nearness to the Martian nodal line. This allows us to keep inclination (i) low and required transfer center angle (η) fairly close to 180 deg. Both are, for reasons of energy limitation, desirable requirements for a capture maneuver near Mars. Thereafter, no favorable constellation for establishing a Mars satellite will occur during the 1960–70 decade. *It would therefore be highly desirable to gain first experience in 1960 with hyperbolic encounter flights.*

The next question of interest is the error sensitivity of these orbits.

The interplanetary probe ascends at a predetermined time from its terrestrial launching site into a low-altitude near-circular orbit, coasts in this orbit until the correct azimuth for hyperbolic escape is reached, and then departs into space along a very nearly hyperbolic orbit, which eventually enters into the heliocentric transfer orbit (heliocentric departure) with a hyperbolic excess velocity (v_∞) which must be added vectorially to the heliocentric velocity ($U_\oplus$) of the earth.

The figure on page 22 describes heliocentric departure. Attention to this figure will help to make clear some of the errors a probe might suffer in traveling to another planet. These we call planetocentric errors, since they accrue from errors in flight path about the planet rather than the sun.

For cotangentical departure ($\beta = 0$) the asymptote parallels planetary velocity vector ($\gamma = 0$). Equation 6 in the table defines the angle γ for a given angle (β) of heliocentric departure. An error (Δv_p) in perigee velocity (vertex velocity of the hyperbola) leads to an error in hyperbolic excess velocity as defined by Equation 7 in the display. For increasingly fast hyperbolas, this error decreases, since the factor v_p/v_∞ decreases. In cotangential departure the change in heliocentric excess is equal to the change in heliocentric departure velocity (that is, $\Delta v_\infty = \Delta V_1$). If planetary velocity (U) and heliocentric departure (V_1) form a heliocentric departure angle (β), then the change ΔV_1 caused by a change Δv_∞ is given by Equation 8, where the error in heliocentric departure angle ($\Delta\beta$) is given by Equation 9 as a function of the velocity error Δv_p.

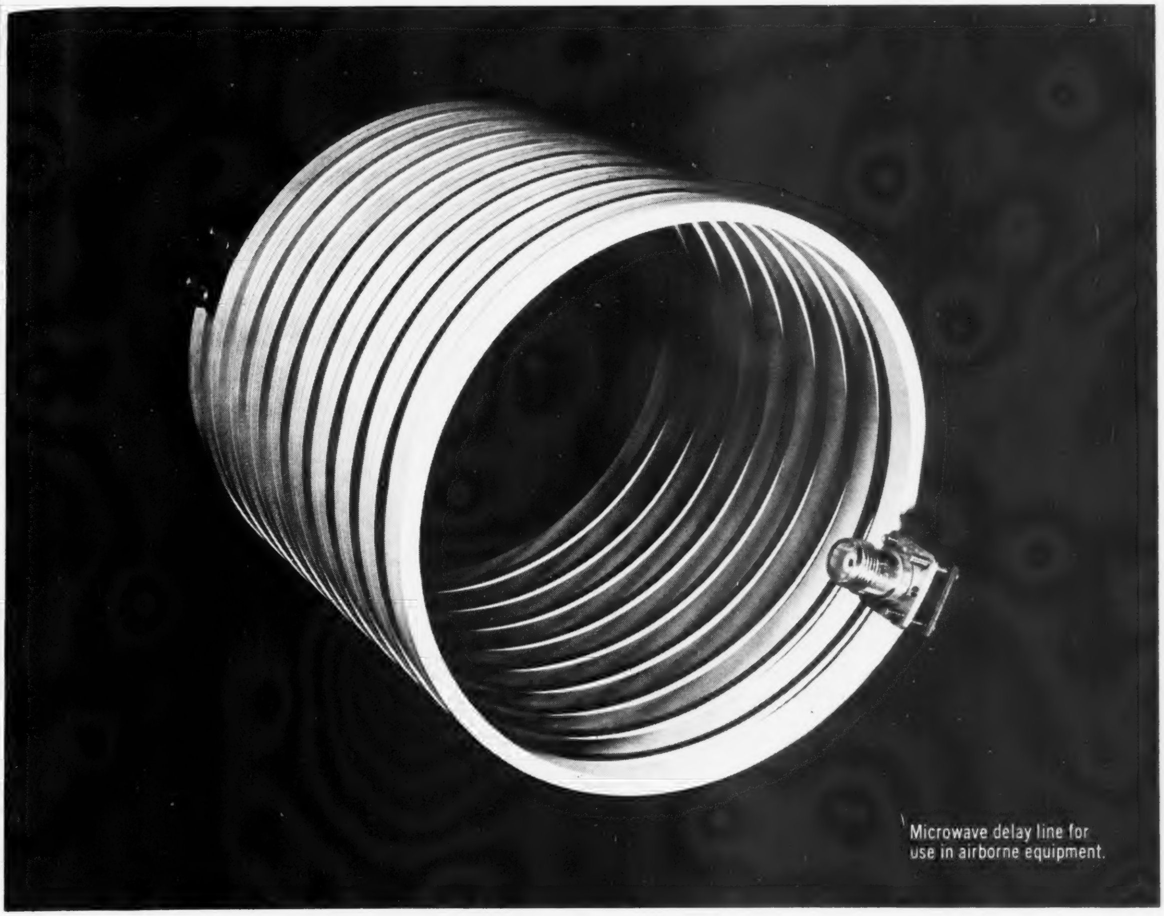
Equation 7 shows that an error in perigee velocity always leads to a greater error in hyperbolic excess velocity. For minimum-energy transfer orbits, the errors are particularly large.

For example, for co-planar transfer from a circular Earth orbit to a circular Mars orbit, the minimum hyperbolic excess velocity is approximately 3.6 fps. For faster orbits this sponding hyperbolic vertex velocity is approximately 36,400 fps at about 300 n. mi. altitude above the Earth. Thus an error in vertex velocity (Δv_p) of 1 fps results in an error in hyperbolic excess velocity of approximately 3.6 fps. For faster orbits this value decreases, being about 2.5 for a 160-day transfer orbit to Mars. The error ($\Delta\beta$) in heliocentric departure direction is negligible for small errors (10-20 fps) in hyperbolic vertex velocity—that is, errors expected from technical inaccuracies in final thrust cutoff with an all-inertial guidance system.

Next, there are the heliocentric departure errors, which arise primarily from three causes:

1. Technical cutoff errors in the hyperbola mentioned above.
2. Uncertainty in knowledge of the combined mass of the Earth-Moon system, which causes an uncertainty in parabolic escape velocity of at least $\pm$ 1 fps.
3. Uncertainty with which the mean Sun-Earth distance is known. This uncertainty is at least $\pm$ 70,000 km out of 1,496,000 km. An uncertainty of $\pm$ 50,000 km corresponds to an uncertainty in the Earth's position with respect to the sun of about 7.8 Earth diameters and to an uncertainty in circular heliocentric velocity of $\pm$ 33 fps at the mean distance, out of 97,770 fps. Of these two uncertainties, the latter is more detrimental to the over-all accuracy of the transfer orbit because of the sensitivity of the transfer orbit to inaccuracies in tangential velocity.

Suppose the heliocentric departure velocity (V_1) is 1 fps too high. The probe will then follow a path displaced from the predicted one in both distance and time. For near 180-deg transfer orbits to Mars, an error in heliocentric departure velocity $\Delta V_1 = +1$ fps displaces R_4 by about 6000 n. mi. further away from the sun, resulting in a displacement of the intersection point with the target orbit of about 350,000 to 600,000 n. mi. Moreover, as a consequence of this velocity error, the probe would arrive about 0.4 days earlier. Since Mars



Microwave delay line for use in airborne equipment.

moves at about 48,000 n. mi./hr, the resulting displacement of the planet is seen to be of the same order of magnitude as the displacement of the probe.

On the other hand, since the inclination of the probe's path with respect to the planet's is very small for 180-deg orbits when $\Delta V_1 = 1$ ft/sec, the two bodies are still likely to approach each other fairly closely, especially in view of some planetary attraction for the probe.

Conditions are different with fast transfer orbits. For example, in a transfer of about 160 days, the displacement of the intersection point is of the order of 40,000 n. mi., for $\Delta V_1 + 1$ fps while the arrival at intersection point is about 3.6 hr, corresponding to a displacement of Mars of 170,000 n. mi. Thus the probe would miss Mars by about 130,000 n. mi. Moreover, the probe's relative velocity to Mars is about three times larger than for the near 180-deg transfer orbit. Consequently, Martian attraction in this case has a considerably smaller focusing effect. Thus we find the error sensitivity of the fast orbit considerably higher than that of the slow orbit.

Midcourse guidance will be desirable in view of possible errors in planetary transfer paths and heliocentric departure velocity. Adequate guidance will depend on measuring rather exactly position and velocity vector of the vehicle en route.

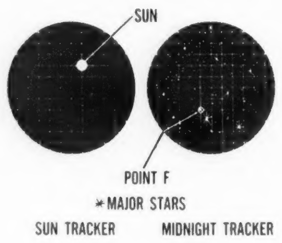
Consider, for example, a fast transfer orbit in heliocentric coordinates to Mars, as depicted in the drawing on page 22.

The drawing shows simultaneous positions of Earth (T) and probe (P) for various stations in the transfer. The angle TSP $= \epsilon$ is initially zero, then reaches a maximum, and finally declines to zero again as Earth passes the probe. Earth does not pass in front of the sun as seen from the probe, because of the inclination of the transfer orbit. The inclination is of the order of several degrees while the sun's diameter is only about 26 min of arc. Subsequently, the angle ϵ increases monotonously as the vehicle proceeds to the encounter point.

The only celestial body in the same orbital plane as the probe in heliocentric space is the sun. Moreover, instruments in the probe can find the sun easier than they can a planet. If the probe could observe the sun and its surrounding stellar configurations with optical instruments, and transmit pictures of these to Earth, it would theoretically be possible to determine the heliocentric longitude and latitude of the sun as seen from the probe. Because of the enormous brightness of the sun, however, it is not possible to photograph surrounding stars at the same time. They would be visible only if the eye or camera was shielded from the sun by a black disk slightly larger than the solar disk.

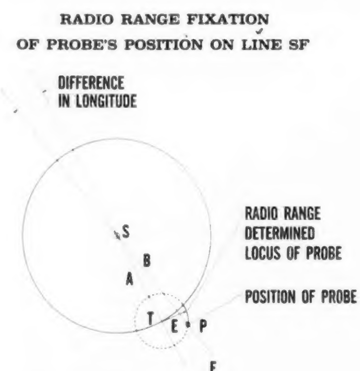
Therefore, it appears more advisable to photograph simultaneously and on a common reference grid the sun and the stellar sky 180 deg opposite it, illustrated below. Then the angle

OPTICAL DETERMINATION OF THE SUN'S POSITION WITH RESPECT TO THE PROBE



ϵ can be found accurately by comparing the longitude of the probe's midnight point (F) with Earth's (F'). The difference in celestial latitude of the sun indicates the orbital plane of the probe. The difference in celestial longitude of the sun provides a line from the sun in the direction of the probe. Somewhere on this line the probe must be located. Radio range measurements can fix the position of the probe, illustrated below.

RADIO RANGE FIXATION OF PROBE'S POSITION ON LINE SF



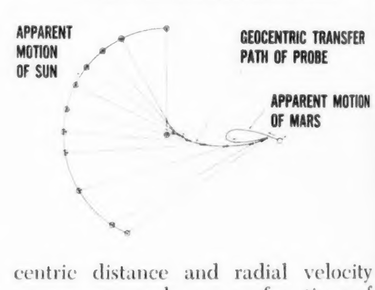
From three or more position measurements of this type, the probe's orbital elements can be determined, and therewith also the accuracy of its encounter with the target planet. This system is exceedingly simple, requiring essentially only one optical instrument. The requirement for picture transmission represents a power drainage; but this power can be made available with solar batteries, especially since only two shades have to be transmitted.

The actual transfer orbit most likely will indicate the need for a correction maneuver. Following this maneuver, the new orbit can be determined in the same manner. Somewhat less, though for many purposes of hyperbolic encounter acceptable, accuracy is obtained by checking the corrected orbit in geocentric coordinates.

This method utilizes the fact that, once in heliocentric space between Venus–Earth or Earth–Mars, the orbit plane of the probe is invariant. The plane cannot be significantly changed either by planet perturbation nor by the correction maneuver. This is seen by taking Equation 5, replacing U ⊕ by the vehicle's heliocentric velocity V, and computing inclination (i) for a velocity change (Δv_i) of 20 fps, which in fact would represent an extreme inaccuracy of the correction maneuver; inclination (i) will be found to be extremely small. This applies to a tilt of the velocity vector in pitch (orbit plane) as well as in yaw (flight direction). Thus, if the correction impulse is but approximately tangential, the effect on the orbit will in essence be the same as if the impulse were exactly tangential.

Having determined the orbit rather exactly prior to the correction maneuver, it is therefore possible to plot the new orbit as it should be after the correction maneuver (assuming this to be essentially tangential). The new orbit is transformed into geocentric coordinates as shown by the illustration below. Therewith its geo-

FAST TRANSFER ORBIT TO MARS IN GEOCENTRIC COORDINATES



centric distance and radial velocity component are known as functions of time. By means of radio-range and radio-Doppler measurements, which measure these two parameters very accurately, the accuracy of the correction maneuver can be determined without transmitting pictures, and it can be determined whether or not additional correction maneuvers are required.

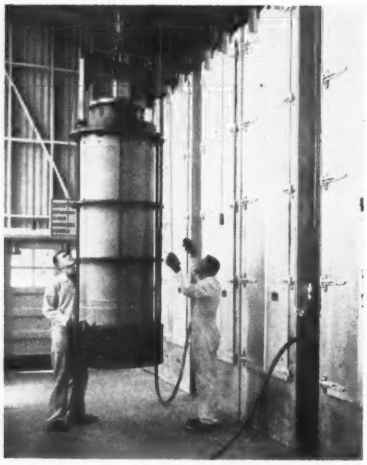
Correction maneuvers require an independent reference system. This can be provided in various ways. One simple method is to use the zodiacal cloud as reference line in conjunction with the line provided by the sun–midnight-point tracker. The zodiacal cloud coincides closely with the eclip-

tic plane. Although it has a certain width, and may therefore cause uncertainties in the reference plane by as much as a few degrees, the resulting error in the correction maneuver is negligible, for reasons given above. A star-tracking system is a more accurate, but also more complicated system. Finally, it is of interest to consider the plane of polarized stellar light as a reference plane.

Correction impulses, unless given very late in the transfer, are comparatively small. For most transfers an impulse corresponding to an ideal velocity of 200 to 400 fps will be sufficient to generate encounter distances of a few 10,000 n. miles. At this distance, good optical instruments in the probe will give considerably greater visible and infrared detail of the Martian surface than is known today, or can be made available even with the aid of satellite optics foreseeable in the near future.

Unclassified excerpts of a paper presented at the USAF(ARDC)-IAF-ARS sponsored Space Exploration Conference, San Diego, August, 1958.

Bake Solid Rockets Like Biscuits



Industrial ovens like this battery recently installed by the Despatch Oven Co. of Minneapolis cure Thiokol polysulfide-polymer-base solid-propellant motors, such as the developmental booster for Nike-Zeus shown on the overhead drane. A thin coating of propellant is baked to the inside of the motor shell; then the main charge is poured around a die-like core in the motor; and finally the whole motor is baked, and the core withdrawn to form the perforation that controls motor burning.

Earth Satellite Orbit

(CONTINUED FROM PAGE 41)

perturbed elliptical elements.

A series of true positions tabulated for certain equal intervals of time can be prepared. Such a table is called an ephemeris. The Nautical Almanac contains a collection of ephemerides, giving, in addition to other data, the right ascension and declination of the sun, moon, and planets at regular intervals of time. Use of celestial coordinates allows the data to be applied all over the Earth. A typical ephemeris for optical or electronic tracking would give the local azimuth, elevation and slant range to the satellite against equal time intervals for one or more geographical locations.

The orbital element of greatest interest to Earth observers is the angle of inclination or, simply, the inclination (i) of the orbit—the angle between the plane of the satellite's orbit and that of the Earth's equator, and, incidentally, the angle between the Earth's axis and the axis of the orbit. Its value determines the maximum north and south latitudes covered by the satellite, and consequently the total amount of the Earth's surface observable by the satellite.

Due to the Earth's rotation, the angle at which the orbit crosses the equator differs from the angle of inclination. For example, Sputnik I's 65-deg inclination resulted in an equatorial crossing angle of $71^1/_2$ deg. Fired in an easterly direction, a satellite will always show some easterly component when viewed from the Earth, and the obverse occurs for one fired westerly, i.e., opposite the rotation of the Earth. By convention, a satellite launched westerly has an inclination greater than 90 deg; thus its orbit is called retrograde.

Finally, although the equatorial crossing angle is not equal to the inclination, the maximum north and south latitudes attained are equal to the inclination.

Next Orbital Element

The next orbital element which helps define spatial orientation of the orbit is the right ascension of the ascending node (α_Ω), which fixes the aspect of the orbital plane, i.e., the direction in which it faces within the solar system. Right ascension is the angle at the center of the Earth from the vernal equinox (γ) to the ascending node, as measured in the equatorial plane in an easterly direction.

Nodes are the points where the satellite orbit pierces the equatorial plane. The node from which the satellite travels north is termed the ascending node (N), and the second node (180 deg opposite), from which the satellite proceeds south, is called the descending node (N'). The line joining the two nodes marks the intersection between the plane of the equator and the plane of the orbit, and is called the line of nodes. The ascending node is used for primary references.

The right ascension of the nodes gradually decreases, as illustrated in the drawing on page 41. This motion, opposite to that of the Earth (regression of the nodes, occurs at a rate of approximately 5 deg per day. For Explorer I, regression amounted at first to 4.26 deg per day. The regression of the nodes is a precession caused by the Earth's equatorial bulge. Regression always decreases right ascension, and hence is sometimes called motion minus.

Orbit's Position Established

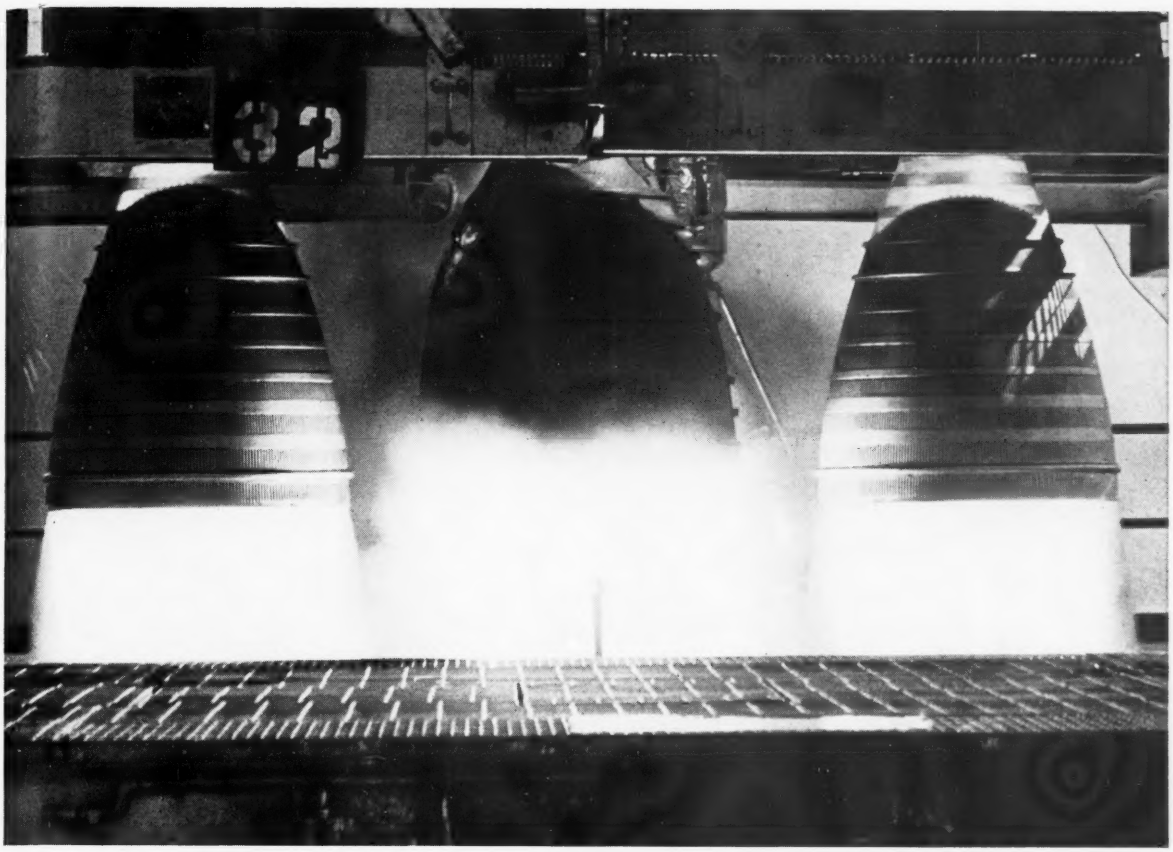
We have now established the orbit's position within an inclined plane and the direction in which this plane faces the solar system. Many orbital shapes and sizes can lie within this planar reference. Two elliptical values are needed to fix the shape and size of the orbit: Eccentricity (e) and the semimajor axis (a).

From the eccentricity and the semimajor axis, the other dimensions of the ellipse can be deduced as follows: Apogee distance $= a(1 + e)$, perigee distance $= a(1 - e)$, and semiminor $= a(1 - e^2)^{1/2}$.

Then, because an infinite number of ellipses of the correct size and shape could lie in the orbital plane, another element is needed—the argument of the perigee (ω). This angle, defining the direction of the major axis of the orbital ellipse within the plane, lies between the ascending node and the perigee, as measured in the plane of the orbit in the direction of the satellite's motion. Because of geodetic effects, perigee does not stay fixed in space but advances a few degrees each day. This motion is called the advance of the perigee (ω) or, since it is always advancing, motion plus.

These five elements (i, α_Ω, ω, e, and a) establish orbital geometry, and by the laws of celestial mechanics imply a calculable velocity regime. Owing to perturbations, rotation of the earth, noncentral gravity field, uncertain air-density distribution, and other peculiarities, a satellite does not, however, have one simple period which can be used for prediction of its future position.

Three important periods are com-



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monly used: The radial anomalistic period (time from one perigee passage to the next); the nodical period (time between successive passages of the satellite through the ascending node); and the sidereal period (time for a complete revolution in right ascension). It is also possible to define the orbital motion in other terms, for example, by mean motion (n), the average angular motion per unit time (radians per second, degrees per day, or similar units), and mean daily motion (μ).

The principal parameter required to make use of orbital elements in predicting the position of the satellite is the epoch, or starting point in time. Generally, the epoch is given as the date-time of passing perigee; but passage of the satellite through other reference points can be used. For the latter, the true anomaly—angle from perigee to center of Earth to satellite at the given instant—is used to establish the actual position of the satellite in the orbit at any instant.

Another position reference used as an epoch point is the mean anomaly at epoch (M). This is a measurement of convenience given by the expression $M = n(t - T)$, where n is mean motion ($2\pi/P$, the sidereal period), t any given time, and T time of perigee passage. The mean anomaly at epoch is therefore an angle ranging from zero at perigee and increasing uniformly at a rate of 360 deg per orbital period.

As noted above, osculating elements cannot be used directly to predict the actual future positions of the satellite with respect to either inertial space or the Earth, owing to various satellite perturbations, caused chiefly by the Earth's noncentral gravitational field and atmospheric resistance, which, dissipating the satellite's energy, makes its orbit approach a spiral.

Gravitational Anomalies

Gravitational anomalies are caused by the difference between a true gravity field and the strange one actually exhibited by the terrestrial spheroid. The Earth is not really spherical but bulges equatorially by a ratio of about 1:298. The satellite is therefore attracted to the Earth by a net force not proportional to the inverse square law. Also, the force is not directed exactly toward the center of the Earth due to the nonhomogeneity of the Earth's mass distribution. For inclined orbits, the bulge effect is directed so as to try to decrease the inclination of the orbit. However, as indicated in the drawing on page 41, gyroscopic precession transforms this force into a uniform precession of the orbital plane and constant rotation of perigee within the plane. As previously noted, the first of these is called regression of the nodes, the second, advance of the perigee. Satellites will provide information on the Earth's gravity field through analysis of orbital perturbations of these types.

The rate of change of the argument of the perigee is a relatively small value; and, for a typical close-in orbit, the perigee of the osculating ellipse will change in position with respect to the plane of the equator roughly 12 revolutions in two years.

The effect of air resistance on a satellite depends on its mass and drag. Neither the drag law nor drag coefficients for bodies passing through an oblate envelope of rarified gases at high velocity are known. Surprisingly, air resistance speeds up a satellite by forcing it into a smaller, lower energy orbit, where the smaller semimajor axis produces a shorter period of revolution, causing the nodical period to decrease.

There is a second peculiarity of air resistance. For satellites within the Earth's atmosphere, the apogee distance decreases more rapidly than the perigee distance, because the elliptical orbit's velocity is least at apogee, and represents a lower energy state. When there is air resistance, the apogee descends faster and faster until the orbit is nearly circular. Then the perigee and apogee should descend at nearly equal rates. For elongated orbits, this difference can be very large. For a 300 km perigee and 700 km apogee, for example, a drop of 100 km in altitude of apogee will produce only 6 km drop in perigee.

This leads to two conclusions concerning any satellite orbiting in the atmosphere. Eccentricity approaches zero as time passes, causing the orbit to seek circularity, and the lifetime is proportional to the initial perigeal altitude. Increasing apogee brings much less increase in lifetime than does increasing perigee. For example, a 360 by 1500 km orbit, if increased 20 km in the perigeal altitude, would be increased in lifetime about 40 per cent. The same change in apogee would increase lifetime about 2 per cent.

Other Perturbing Forces

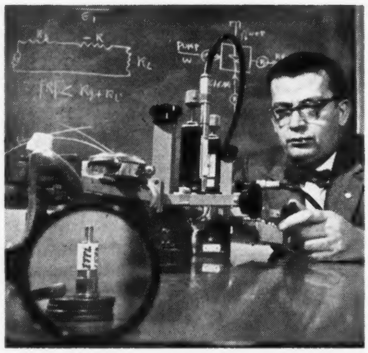
There are many other perturbing forces, some calculable and others only vaguely recognized. The disturbing activities of other celestial bodies, principally the sun and moon, are small but perhaps significant for long-time orbits. The motions of the Earth underneath the orbit present a turning panorama of nonhomogeneous mass areas (e.g., water vs. land), and further complicate the satellite-Earth scheme. The Earth's magnetic field may contribute drag, precession of the satellite's orbit, or changes to the spatial orientation of the satellite itself, particularly if it is spin-stabilized.

Over long periods of time, the Faraday effect exercises a significant retarding force on a spinning conductive body cutting through the Earth's magnetic field. Eddy currents induced around a spin-stabilized body can cause it to stop spinning, perhaps very quickly. Ionized sheaths around a satellite may interact with the existing natural fields in unknown ways. Impacts from meteoroids may deflect a satellite. Differential heating may cause torques which can move the satellite's spinning body according to precession rules. The effect of "wind" due to the atmosphere being rotated with the spinning Earth can also be a significant factor for long lifetime orbits.

Even without these disturbing forces, and perhaps others as yet unknown, orbital elements are true constants only for arbitrary instants chosen for mathematical convenience. Between these instants, orbital elements progress, regress, decay, and precess in a myriad of independent and interdependent ways, both periodic and secular.

Playing against the harmonic motions of the Earth, a satellite gives, we can see, a Lissajous trace of supremely harmonious smoothness, inspiring to contemplate and a challenge to analyze.

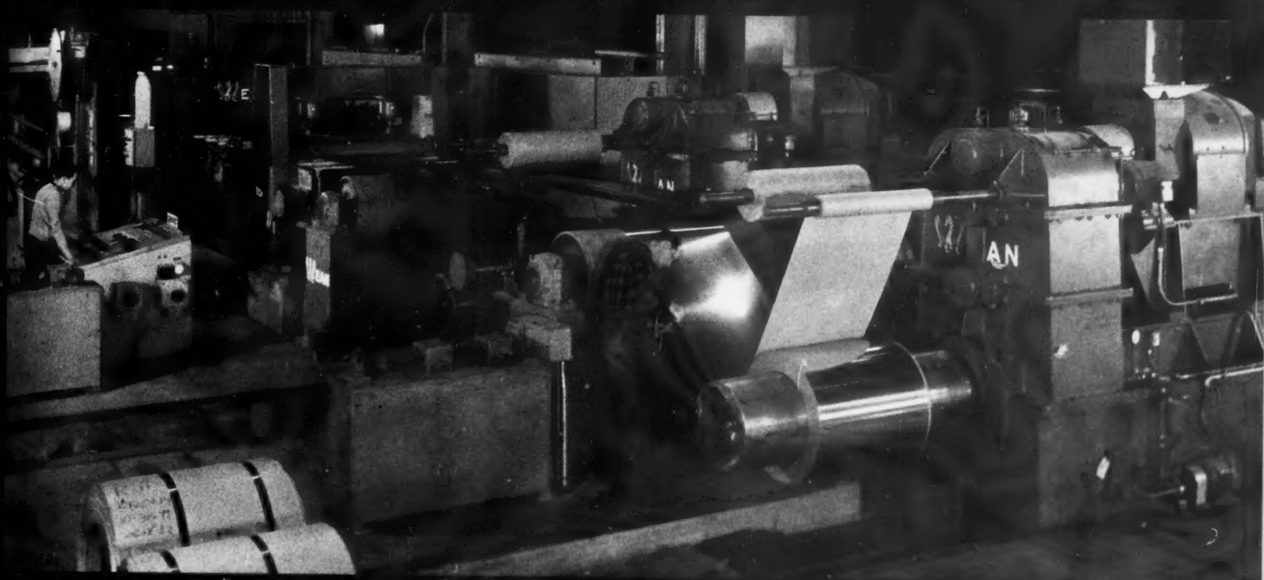
A Hundred-Mile Step For O/H Radio Links



ITT has in the laboratory stage a parametric amplifer, based on a new ITT-developed silicon diode, which will add 100 miles to the present 250-mile range of over-the-horizon (O/H) radio links. Above, William Sichak, director of ITT radio communication lab, adjusts laboratory version of amplifier.

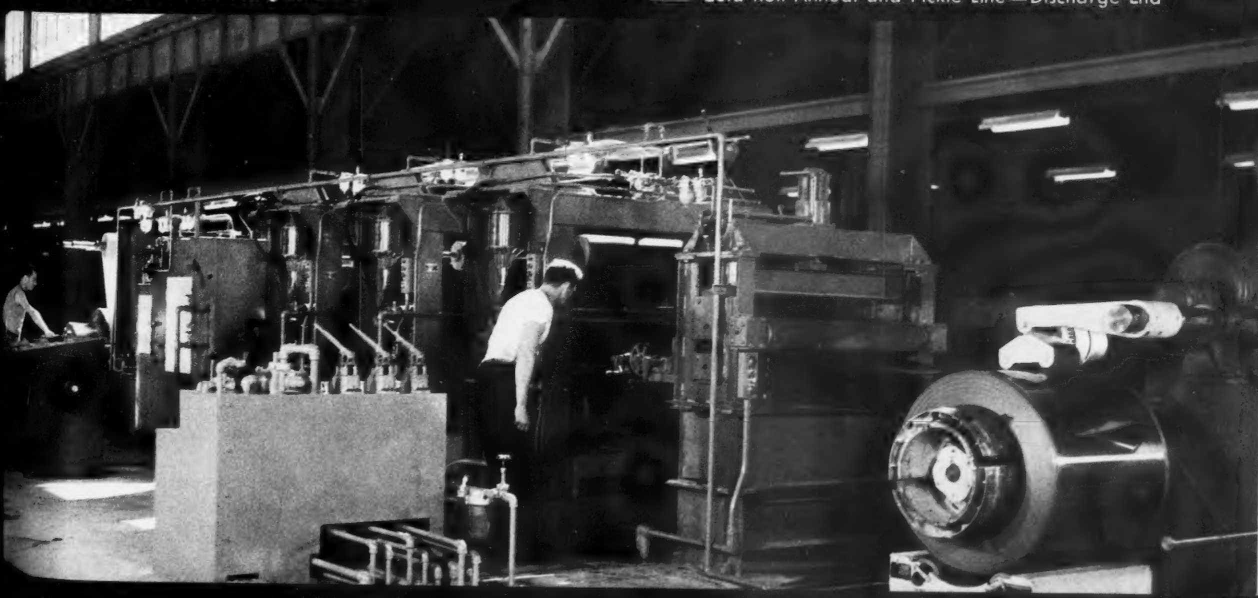
The Sendzimir Mill

Interior View of the Intricate Mechanism of the Sendzimir Mill



Cold Roll Anneal and Pickle Line—Discharge End

Scouring and Scrubbing Line



ARS news

Telemetering Conference Set for May 25-27

Theme of the 1959 National Telemetering Conference, to be held May 25-27 at the Cosmopolitan Hotel in Denver, Colo., is "Investigation of Space," it has been announced by Max A. Lowy, Data Control Systems, Inc., conference chairman and chairman of the ARS Communications Committee.

The conference is sponsored annually by ARS, IAS, AIEE, and ISA, with ARS acting as the host society this year.

Tentative meeting schedule calls for 12 technical sessions, covering such subjects as calibration techniques, transistorization, special telemetry techniques, miniaturization, ground stations, data processing, biomedical telemetry, and space telemetry measurement and control. A panel discussion on the future of telemetering technology is also scheduled. Allan P. Gruer of Sandia Corp. is program chairman.

A special exhibit of telemetry and data processing equipment will be held at the Cosmopolitan Hotel during the conference.

Deadline date for submission of titles is Jan. 15, with final manuscripts due March 19. Titles and papers should be submitted to Allan Gruer, Sandia Corp., Albuquerque, N.M.

The conference committee, in addition to Lowy and Gruer, consists of Hugh Pruss, Telemetering Corp. of America, vice-chairman; R. Francisco, GE Missile and Space Vehicle Dept., secretary; Ralph Schmidt, Avco, publicity chairman; Elliot Ring, C. Benavides, and Joseph McKenna, Martin-Denver; J. L. McKinley, Public Service Co. of Colorado; J. Winters, Thompson Ramo Wooldridge; and F. Venditti, Denver Research Institute.

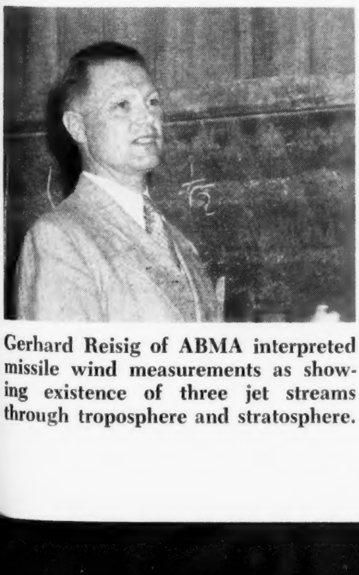
Max A. Lowy
Conference Chairman

Allan P. Gruer
Program Chairman

First National High-Atmosphere Conference Held

More than 200 meteorologists and rocket scientists attended the First National Conference on the High Atmosphere in El Paso, Tex., Oct. 14–16. This conference was sponsored jointly by the El Paso Section of the American Meteorological Society and the New Mexico-West Texas Section of ARS.

Two sessions on the behavior of the ionosphere, under the chairmanship of David M. Gates and Millett G. Morgan, touched off the meeting. In two fine papers given in the first session, L. R. Megill of the NBS, Boulder, Colo., described photometric observations of 5577 and 6300 Angstrom light in the airglow and at twilight. His data shows that this light emanates from broad cells in the upper atmosphere that migrate and rotate horizontally. Pronounced differences in dawn and evening twilight were observed.



Gerhard Reisig of ABMA interpreted missile wind measurements as showing existence of three jet streams through troposphere and stratosphere.

In another outstanding paper from this session, S. Matsushita of the University of Colorado High-Altitude Observatory described a rather elaborate breakdown and analysis of geomagnetic observations that provide a description of the low ionospheric part of the atmosphere. A fine structure of wind and electric current systems near the 100-km level was deduced from the results.

On Oct. 15, interest turned to rocket systems for meteorological studies and some of the operational problems associated with the systems. Lt. Comdr. W. S. Houston of ONR presented a report on ARCAS, a low-cost meterological research rocket developed by Atlantic Research for the Navy. This rocket was designed to reach a minimum altitude of 200,000 ft with a 10-lb payload. ARCAS flights to obtain temperature and wind profiles are expected to begin early in 1959.

The Exos, consisting of three off-the-shelf stages—Honest John booster, Nike-booster second stage, and Recruit third stage—was described by L. M. Jones of the Univ. of Michigan Research Institute. This rocket can carry a payload of 40 lb to an altitude of nearly 300 miles. Two test flights have been made. The first, launched at an angle of 75 deg, reached an altitude of approximately 240 miles. The second, launched at an angle of 80 deg, reached the predicted peak altitude of 288 miles. Serious problems arise in the instrumentation of the Exos owing to high nose cone temperature caused by high velocity at burnout of the third stage.

Also in this session, Harold A. Daw of New Mexico College of Agriculture and Mechanic Arts presented a new wind-weighting theory to be used for predicting impact location of fin-stabilized rockets. Simulated flight trajectories are being computed on an IBM 650, but numbers were not available at the time for comparison with the Lewis theory.

About 125 attendees availed themselves of the opportunity to visit White Sands Missile Range and see some rocket operations firsthand on Wednesday afternoon.

The evening was devoted to the

This panel discussed problems of high-altitude meteorological research. Members, left to right, were Robert Fletcher, Hans AufnKamee, Lt. Comdr. W. S. Houston, Comdr. Nelson B. Ross, C. Y. Johnson, W. W. Kellogg (chairman), Gilbert Moore, David Gates, A. J. Ruhlig, David S. Johnson, and S. Matsushita.

banquet, at which Alan H. Shapley, vice-chairman of the U. S. National Committee for the IGY, spoke on "The IGY Stimulus to High Atmosphere Research."

The last day of the meeting was devoted to technical papers and a panel discussion. Gerhard Reisig of ABMA elicited many questions regarding a wind measuring method he described that can be used during guided missile flight. The method also yields wind-gradient values, which are considered highly realistic since they are derived from instantaneous windspeed measurements. Measurements were carried out on ABMA missiles at Cape Canaveral. Reisig interpreted certain of the data as showing the existence of three jet streams throughout the troposphere and stratosphere.

Also, a unique method of observing very high-level winds was accidentally discovered when it was noticed that drifts from intense light flashes used for determining re-entry trajectories existed. David D. Woodbridge of ABMA described the drifts and showed photographs made with tracking cameras. Unfortunately, because a chopper was not incorporated in the shutter, quantitative data were not obtained.

The panel discussion served to summarize the proceedings of the conference and bring it to a close.

Special credit should go to Willis L. Webb, president of AMS, Keith Hennigh, president of the local ARS section, and T. G. Barnes, program committee chairman, for an exceptionally well-conducted meeting.

—Russell K. Sherburne

Florida Conference Chairman Named

James F. Thompson, contract administration manager for RCA Service Co. at AFMTC, has been named general chairman and John Sterner, director of the flight test operations staff of Space Technology Laboratories at AFMTC, technical program coordinator for the ARS 1959 Flight Testing Conference, to be held at Daytona Beach, Fla., March 23–25. The meeting, will include a classified tour of Cape Canaveral as well as technical sessions on such subjects as checkout and ground support, launching and flight problems, instrumentation and guidance, data reduction systems, and missile test ranges. An attendance of 500–800 is expected.

James F. Thompson
General Chairman

John Sterner
Program Coordinator

ARS Slates Controllable Satellites Conference

The ARS Controllable Satellites Conference will be held at MIT April 30 and May 1, with sessions in Kresge Auditorium on guidance and control, vehicle design and recovery, electrical propulsion, and external environment problems. The Conference will also feature a seminar on the physics of the atmosphere.

To be considered for this conference, technical papers should be submitted as soon as possible to general chairman Peter Rose of Avco Research Lab, 2385 Revere Beach Parkway, Everett, Mass., or to program chairman George Sutton, Aeronautical Engineering Dept., MIT, 77 Massachusetts Ave., Cambridge, Mass.

A complete schedule of the ARS Controllable Satellites Conference will be mailed to the membership in March.

Peter Rose of Avco Research Lab will chair Controllable Satellites Conference.

ARS Preparing Report On Amateur Rocketry

A full-scale report on amateur rocketry will be published by ARS in the near future. The report, prepared by a special ad hoc committee of the Southern California Section, has been approved by the Section's Board, as well as the ARS National Board. Covering such subjects as the nature of rocketry, the status of amateur rocketry today and recommended courses of action, the report will be circulated to all ARS Sections.

Astronautics at Maryland

During the fall, the Univ. of Maryland sponsored a "Space Research and Technology Institute," which consisted of eight lectures: "Interplane-

tary Flight Objectives and Methods," by Krafft Ehricke; "Chemical, Nuclear and Ionic Propulsion," by Howard Seifert; "Manned Space Flight," by Arthur Kantrowitz; "Space Flight Instrumentation," by Ernst Stuhlinger; "U.S. Space Program," by Herbert York; "Satellite Results," by John Hagen; "Astronomy in Near Space," by Ernst Opik; and "Space Medicine, Astrobiology," by Hubertus Strughold.

Kansas City Section Forming

A Kansas City section of ARS began organizing formally in a meeting of prospective members at the Linda Hall Library of the Midwest Research Institute Nov. 18. Alan R. Pittaway of Midwest Research was elected temporary chairman of the section at a previous briefing meeting, and Paul Klevatt of Westinghouse Aviation Gas Turbine Div. was elected secretary pro-tem.

Charles R. Burke of Westinghouse, as spokesman for the founding group, reported that the proposed section already had 43 members, most of them from Midwest Research, Westinghouse, Spencer Chemical, RCA, Forbes Air Force Base at Topeka, and the Command and General Staff School at Fort Leavenworth. Meetings to complete organization and to elect officers were to be held in December.

On the calendar

1959

Jan. 26–29	27th Annual IAS Meeting, Sheraton-Astor Hotel, N.Y.C.
Jan. 28–29	1st International Symposium on Nuclear Fuel Elements, sponsored by Columbia Univ. and Sylvania-Corning Nuclear Corp., at Columbia Univ., New York, N.Y.
Jan. 28–29	5th Annual Midwest Welding Conference, sponsored by Illinois Inst. of Technology and American Welding Society, IIT Chemistry Bldg., Chicago.
Feb. 3–5	14th Annual Technical and Management Conference of the Reinforced Plastics Div. of The Society of the Plastics Industry, Edgewater Beach Hotel, Chicago.
Feb. 5–6	Industrial Management Engineering Conference at Illinois Inst. of Technology, Metallurgical and Chemical Engineering Bldg., Chicago.
March 3–5	1959 Western Joint Computer Conference, sponsored by IRE, AIEE, and Assn. for Computing Machinery, Fairmont Hotel, San Francisco.
March 8–11	Turbine in Action Symposium, sponsored by ASME Gas Turbine Div., Cincinnati, Ohio.
March 19–20	Flight Propulsion Meeting, sponsored by IAS, Hotel Carter, Cleveland, Ohio.
March 23–25	**ARS Flight Testing Conference, Daytona Beach, Fla.**
March 31–April 2	Millimeter Waves will be the theme of 9th International Symposium of Polytechnic Institute of Brooklyn (N.Y.) Microwave Research Inst., co-sponsored by AFOSR, Army Signal R&D Lab, ONR, and IRE.
April 5–10	5th Nuclear Congress of Engineers Joint Council, Cleveland Auditorium, Ohio.
April 6–10	40th Annual Convention of the American Welding Society, Chicago.
April 20–22	**ARS Man-in-Space Conference, Hotel Chamberlain, Hampton, Va.**
April 22–24	3rd Annual Technical Meeting of the Inst. of Environmental Engineers, LaSalle Hotel, Chicago.
April 30–May 1	**ARS Controllable Satellites Conference, MIT, Cambridge, Mass.**
May 4–7	5th ISA National Instrumentation Flight Test Symposium, Seattle, Wash.
May 25–27	**National Telemetering Conference, co-sponsored by ARS, AIEE, IAS, and ISA, Denver, Colo.**
June 8–11	**ARS Semi-Annual Meeting and Astronautical Exposition, San Diego, Calif.**
June 11–13	1959 Heat Transfer and Fluid Mechanics Institute, Univ. of Calif., Los Angeles.
Aug. 24–26	**ARS Gas Dynamics Symposium, Dynamics of Conducting Fluids, Northwestern Univ., Evanston, Ill.**
Aug. 31–Sept. 5	**10th Annual International Astronautical Federation Congress, London, England.**
Sept. 24–25	**ARS Solid Propellants Conference, Princeton Univ., Princeton, N.J.**
Nov. 16–20	**ARS 14th Annual Meeting and Astronautical Exposition, Washington, D.C.**

SECTIONS

Alabama: The section is sponsoring an essay contest on astronautics among local high school students. Part of the first- and second-place awards will be student memberships in ARS.

Central Colorado: Members and guests met in the photo lab of Lowry Air Force Base Oct. 29 to hear guest **Leslie W. Leroy,** professor of geology at Colorado School of Mines, discuss the geology of the moon, a subject to which he has devoted special study the past two years. This proved an interesting topic in view of recent proposals to build a moon station.

Columbus: Some 30 members and guests gathered at the auditorium of the Battelle Memorial Institute, Oct. 14, to discuss the coming annual meeting of ARS, to review the formation of a women's auxiliary and to hear guests, **Arthur S. Cosler Jr.** and **Urho A. Uotila,** executive director and research associate, respectively, of Ohio State Univ. mapping and charting laboratory, discuss "Application of Gravity Research to Missile Guidance Problems."

This laboratory is the only place in the western hemisphere which is doing extensive research in mapping and charting with intensive efforts in gravity measurements. It was explained how long-range missiles and, particularly, the satellites are making more accurate mapping possible. Conversely, it was shown why it is necessary to know the exact location of any desired target point in order to direct a missile to it.

At present, different countries use different ellipsoids to represent the Earth, none of which truly represents the geoid. Even though adjacent countries might adopt a common ellipsoid, the speakers noted, the various networks, such as those used in the U.S. and Canada, cannot be tied in to those used in Europe and other continents because of the lack of information and the complications of a water bridge. Moreover, because of large adjacent land masses, extreme deviations from the true normal can

be found in various local areas. Also, variations in the acceleration of gravity as high as 300 milligals have been noted.

The speakers pointed out that these effects in combination can greatly alter the course of a long-range missile even though all of its internal guidance equipment functions satisfactorily. Slides and examples were used effectively to illustrate the authors' points. A lively question and answer period followed the talk.

Members met at Battelle the evening of Nov. 11 to hear **Galen A. Holcomb,** escape systems and human factors specialist of North American Aviation's Columbus Div., discuss design concepts and testing methods for aircraft and spaceship escape systems. He described the use of rocket sleds to test escape systems and showed movies of sled tests.

Last but not least, the Women's Auxiliary of the section held a pot-luck supper Nov. 8 to plan community work.

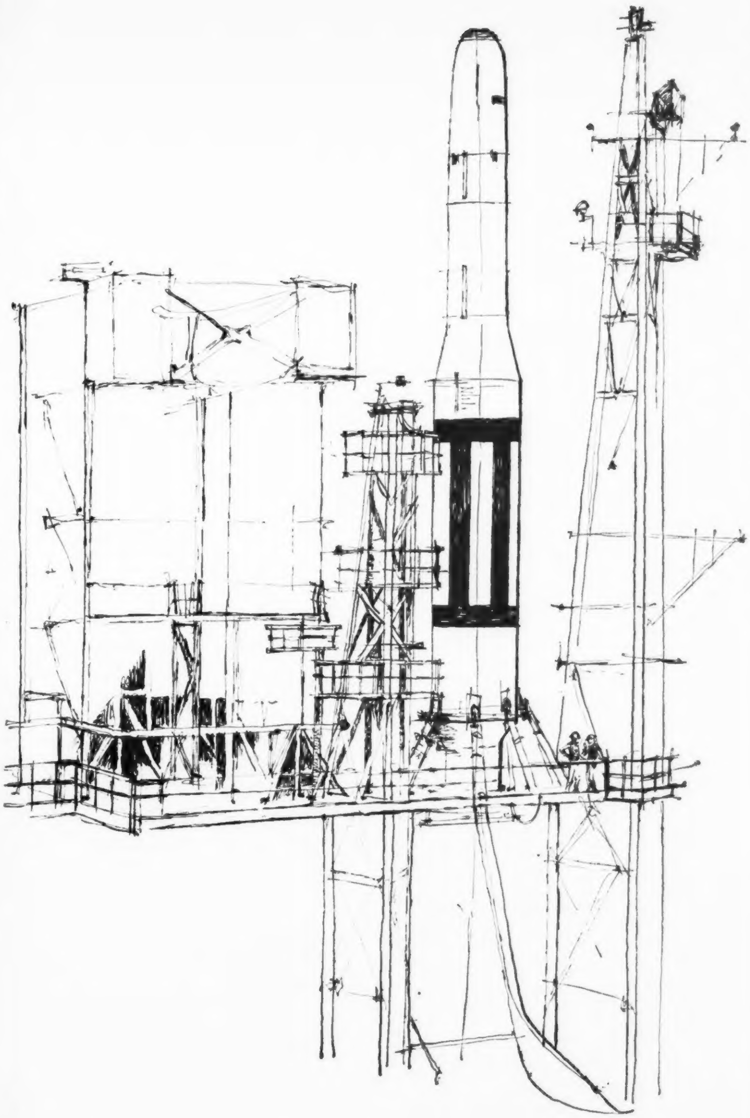
—Dean L. Pendleton

Detroit: The section sponsored the attendance of two student ARS members—Ronald E. Polzein, a senior at Wayne State Univ., and J. B. Bullock, a graduate student at Univ. of Michigan—to the Student Conference of the ARS 13th Annual Meeting.

Indiana: A dinner meeting, with Indiana Gear Works as host in a preliminary reception, was held at the Sheraton-Lincoln Hotel in Indianapolis Nov. 5. Speaker of the evening was **Herbert L. Karsch,** now planning director for missile systems at GM's Allison Div. and previously director of the AF Farside program and the Army's antitank-vehicle weapon systems project at Aeronutronic Systems, Inc. On the Farside program, which he discussed at the meeting, he was responsible for vehicle development, flight dynamics and data-link systems.

Northeastern New York: Members and guests attending a dinner meeting Nov. 11 heard **Richard Gompertz,** manager of engineering for GE's Rocket Engines Section and former director of the Rocket Engine Test Station of Edwards AFB, describe the testing of manned rocket aircraft at Edwards.

Pacific Northwest: The section held its first fall meeting in October at the Univ. of Washington. Guest speaker was **Col. John L. Martin Jr.,** ARPA deputy director for advanced technology, who outlined the program and operation of ARPA. He also showed a movie of one of the AF centers where basic research is being conducted in a space chamber. Part of



this movie showed an experimenter clad in a space suit performing falling-object and friction tests in an atmosphere simulating outer space. A second movie showed a successful launching of an Atlas ICBM. In conclusion, Col. Martin outlined the benefits that mankind will derive from space flight. This was a fine presentation, and a well-attended meeting.

—**Michael Guidon III**

San Diego: On Oct. 22, some 60 members of the section heard two technical lectures. **W. H. Schwidetzky,** director of computers and flight simulation at Convair-Astronautics, discussed "Satellite Orbits in the Force Field of the Oblate Earth." He noted that satellite data has already improved the accuracy of man's knowledge of the "flattening" of the earth at the poles from the historical value of 1/297 to 1/298.2. He explained that recession of the nodes of an orbit is caused by the earth's oblateness and the manner in which it varies with altitude and orbital inclination. Dr. Schwidetzky also described the normal and tangential forces caused by earth's shape which tend to rotate an elliptical orbit in its plane.

The second speaker was **G. M. Hanley** of the Convair-Astronautics aerophysics group, who talked on "Glide Vehicles for Re-entry from Satellite Orbits." He felt guide vehicles must be used for human re-entry because of the severe g-levels imposed by drag vehicles. He mentioned negative (inverted flight) re-entry and positive re-entry involving pullup technique, touched on some of the problems in achieving radiation equilibrium temperatures during quasi-steady flight, and showed curves on the effects of angle of attack, sweepback, and wing loading.

These technically informative lectures were well received and encouraged our plans to avoid survey discussions this year.

—**D. A. Heald**

Southern Ohio: The September meeting featured two speakers. **Bernard Free** began the meeting with a demonstration of the IBM 704 Digital Computer. After a brief description of the basic fundamentals of operation, he explained how the 704 can be used to determine performance characteristics of propellant combinations. During his talk, the 704 completed the performance calculations of a specific propellant combination, a job which would require about two to three months to do by hand.

Then **Thomas Reinhardt,** manager of research for the Bell Aircraft Rocket Div., spoke on "Future Methods of Space Propulsion." It is his opinion

ARS 1959 Paper Deadlines			
Date	**Meeting**	**Location**	**Deadline**
March 23–25	Flight Testing Conference	Daytona Beach, Fla.	Past
April 20–22	Man-in-Space Conference	Hampton, Va.	*
April 30–May 1	Controllable Satellites Conference	MIT	Feb. 20
May 25–27	National Telemetering Conference	Denver, Colo.	March 19
June 8–11	Semi-Annual Meeting	San Diego, Calif.	March 9
Aug. 24–26	Gas Dynamics Symposium, Dynamics of Conducting Fluids	Northwestern Univ.	May 22
Sept. 24–25	Solid Propellants Conference	Princeton Univ.	June 22
Nov. 16–20	14th Annual Meeting	Washington, D.C.	Aug. 17

* No papers. Proceedings will be published after Conference.

Send all papers to Program Chairman, ARS, 500 Fifth Ave., New York, 36, N.Y., or to appropriate committees.

that the need for great quantities of power for space flight has precluded the use of chemical energy and has required the exploration of nuclear and solar sources of energy. He described and evaluated many systems, including fission rockets, plasma and ion drives, and solar energy. He forsees thermonuclear reactors for space propulsion within 10 to 20 years.

The question session following this talk was enlivened by a group of GE-sponsored Science Explorer Scouts, present for the first time at a formal meeting.

—**I. E. Kanter**

STUDENT CHAPTERS

City College of New York: Besides holding the regular Thursday meetings, the Chapter has heard two lectures and made a field trip in the past two months. On Nov. 20, **Jerry Grey** of Princeton spoke and showed slides on recent developments in propulsion, including magnetohydrodynamic, ion, and nuclear systems. On Dec. 4, **Arthur Sherman** of Reaction Motors discussed and showed a color motion picture of RM work for North American's X-15. Chapter members traveled to the Naval Air Rocket Test Station, Lake Denmark, N. J., on Dec. 20 for a guided tour of the installation, a briefing on the kind of work being done there, and a demonstration of an operational rocket motor.

Drexel Institute of Technology: The chapter received its charter in an evening meeting Oct. 19. The president of this new chapter is Eugene J. Boyle, and faculty advisers are F. Smith and C. Etter. The speaker of the evening was **John Bohuslaw**, a metallurgical engineer with GE, who spoke on "What the Future Holds for the Earth Satellite." The Martin Co. is sponsoring the chapter's first field trip, to its Baltimore facilities.

University of Florida: The second fall meeting heard **David T. Williams** of Florida Univ. Aeronautical Engineering Dept. speak on nose cone reentry and illustrate points with a series of slides on meteorites.

CORPORATE MEMBERS

Aerojet-General, U. S. sales agent for the Napier Scorpion liquid propellant rocket engine, has received the first for the market. Recently, an Electric Canberra bomber powered by a Scorpion set an official world's record of over 70,000 ft. Aerojet will sell the engine on an in-stock availability to commercial firms.

Garret Corp.'s AiResearch Mfg. Div. will contribute hydraulic actuators, valves and solenoids for the Talos launcher to be used on the nuclear-powered missile cruiser Long Beach, which is being built now. Prime contractor for the launcher is GE's Ordnance Dept.

Grumman Aircraft announced the formation of a space projects group under the leadership of Oscar Erlandsen, Grumman's Missile Development Director. The group will work on a wide range of projects, including stabilization controls, control systems, avionics, structures, rockets, escape systems, and over-all design.

IBM demonstrated its new "auto-abstracting" equipment at the recent International Conference on Science Information held in Washington, D.C. This equipment, which automatically reads, summarizes, codes, distributes, and files written material, is looked upon as the beginnings of an efficient automatic information center.

Hoffman Electronics has leased a 13,000-sq ft building in Los Angeles to expand its Electro-Mechanical Dept. The building will be used for manufacture and assembly of gyroscopes, gimbal systems, and other precision guidance components.

Lockheed Missile Systems Div. has bought a 154-acre piece of land next to its main plant in Sunnyvale for possible future expansion. Lockheed also holds an option on other adjacent land.

Marquardt Aircraft recently acquired Cooper Development Corp. (36,000 sq ft of floor space) as a wholly owned subsidiary to engage in development and manufacture of multistage rockets, instrumented payloads, and solid-propellant rocket motors. Clifford Cooper, president of the company, will continue for Marquardt as principal executive officer.

North American's Atomics International Div. began occupying last

Jet Propulsion Becomes ARS Journal This Month

Beginning this month, Jet Propulsion will carry the new name, ARS Journal.

The Board of Directors approved this change at the recent annual meeting in view of the rapid growth and diversified interests of the Society. ARS members contribute to every branch of the astronautical sciences, as witnessed by the formation of 22 technical committees to replace the previous eight (see Irwin Hersey's article on page 34). The Board and many prominent members believe this new title reflects better the many Society activities and the balanced coverage of astronautical sciences planned for the Journal.

The ARS Journal will continue to emphasize significant and reliable technical papers and survey articles. Moreover, members can look forward to more as well as a greater variety of articles on the astronautical sciences.

Martin Summerfield, distinguished editor of the Journal, gives a more detailed account of the cover change in an editorial in the January issue.

month the first building completed for its new headquarters at 8900 De Soto Ave. in Canoga Park. The building, one of four being built on a 68-acre plot, has 132,000 sq ft of floor space.

Olin Mathieson is building a $4 million metallurgical center at New Haven, Conn., to provide research, development, and pilot plant service for metals, nuclear-fuel deveolpments.

RCA has formed a high-level R&D organization, Advanced Military Systems, to conceive and develop space-age weapon systems. The group, headed by Nathaniel Korman, will set up shop adjacent to RCA's David Sarnoff Research Center in Princeton.

Solar Aircraft will build a 60,000-sq ft engineering and research building and a large furnace for heat-treating and brazing missile components on its San Diego bayfront leasehold. This facility will increase Solar's space for research and engineering departments some 50 per cent. The furnace will take missile tanks 9 ft in diam and 30 ft long up to 1950 F.

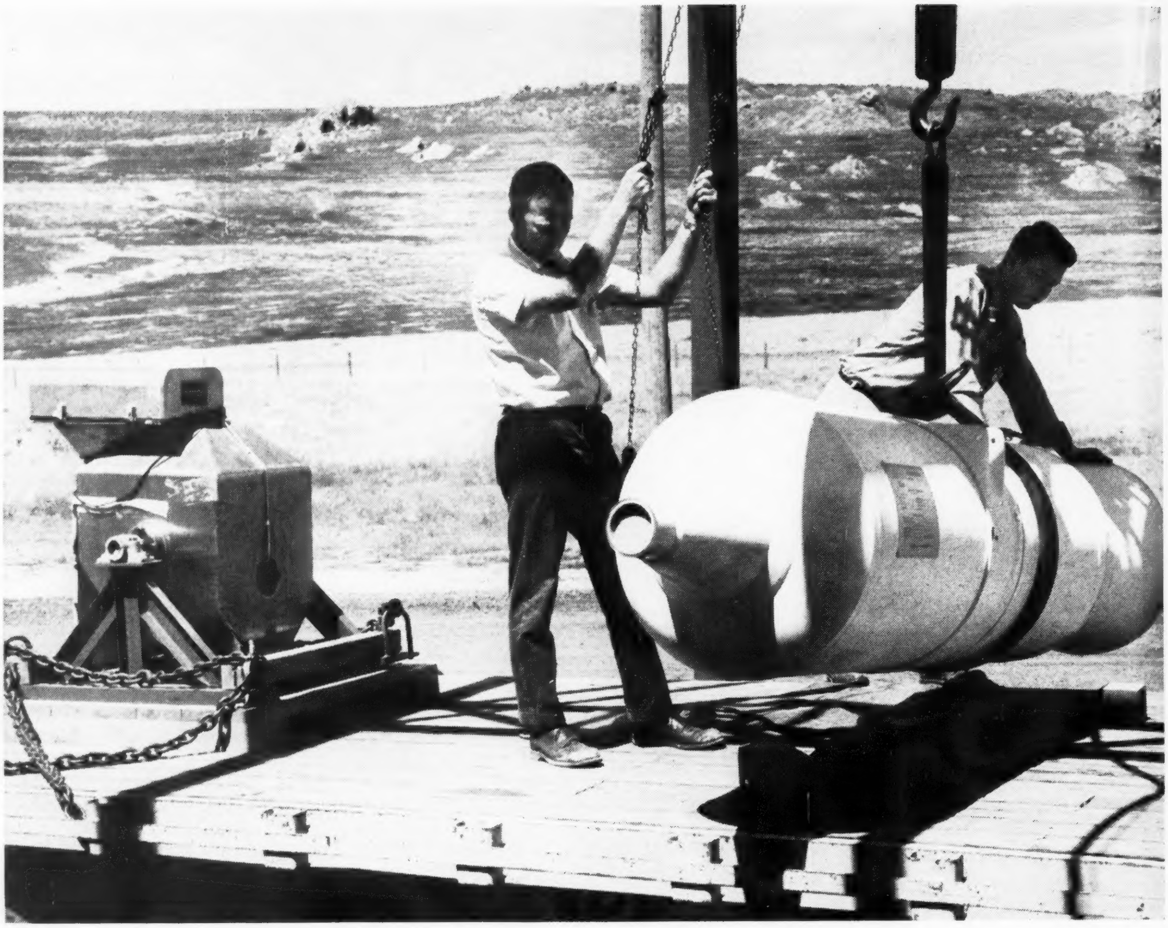
Telecomputing Corp. has acquired controlling interest in the Frank R. Cook Co. of Denver, Colo., in a program to broaden its missile activities. Cook, a missile components firm which has specialized in silver-zinc batteries, will operate as a division of TC.

Stapp Heads ARS for 1959

(CONTINUED FROM PAGE 38)

Systems; Logistics and Operations, Kurt Debus, ABMA; Test Facilities and Support Equipment, Col. Harold W. Norton, Edwards AFB; Space Law and Sociology, Andrew G. Haley; Guidance and Navigation, Lawrence S. Brown, Ford Instrument Co.; Communications, Max Lowy, Data Control Systems; Instrumentation and Control, Herbert Friedman, NRL; Hydromagnetics, Milton U. Clauser, Space Technology Labs; Nuclear Propulsion, Stanley V. Gunn, Rocketdyne; Propellants and Combustion, John Sloop; Ramjet, William Shippen, Applied Physics Laboratory, Johns Hopkins; Liquid Rocket, Y. C. Lee, Aerojet-General; Solid Rocket, Ivan E. Tuhy, The Martin Co.; Human Factors, Maj. Stanley White, NASA Langley Research Center; Physics of the Atmosphere and Space, Milton Greenberg; Education, Paul Sandorff, MIT; Ion and Plasma Propulsion; Underwater Propulsion; Flight Mechanics; Hypersonics; Materials and Structures; and Missiles and Space Vehicles.

Additional committee chairmen, as well as the full make-up of the com-



mittees, will be announced in the near future. A coordinating chairman of the committees will also be named shortly.

Bob Lawrence, referring to himself as "that unusual man, a happy treasurer," noted at the business meeting that the Society is in a healthy financial position, with this year's revenue up some 35 per cent over 1957 and 160 per cent over 1956. Total income of the Society this year topped $625,000, with a further substantial growth anticipated in 1959. Membership also skyrocketed this past year, with some 5000 new members enrolled.

Highlights of the meeting, many shown in the photos on pages 36 to 39, were almost too numerous to mention, but certainly worthy of recognition were the five classified technical sessions; the two special sessions on the AF Pioneer vehicle and Mouse-in-Able program; the annual film night, and the Second ARS Eastern Regional Student Conference.

Other Highlights

Those attending the meeting found much food for thought in the addresses by Simon Ramo, on education in the so-called "Space Age"; by Lt. Gen. James M. Gavin (USA-Ret.), former Army R&D Chief, on commercial applications which have arisen or may arise out of rocketry and space flight; by Roy Johnson, ARPA Chief, on the military space program, calling for development of navigation, communication, early warning, and tactical cloud cover satellites; and by Hugh Dryden, Deputy Administrator of NASA, on how the nation's civilian space agency will operate and its plans for the immediate future.

George Sutton, in a timely address at the Student Conference luncheon sponsored by Thiokol, provided a thorough rundown on amateur rocketry and the physical and legal hazards entailed in unauthorized rocket experiments.

The annual Section Delegates Luncheon and the Conference which followed it on the first day of the meeting provided some interesting sidelights on section activities. Of particular interest was the large number of sections reporting active educational and community service programs. Also significant was the growing concern over amateur rocket experimentation, which led to a heated discussion over what course of action should be followed.

The Annual Honors Night Dinner drew a record attendance of 1150, filling the Grand Ballroom of the Statler to capacity and even overflowing onto the balcony. The evening was

highlighted by the presentation of awards to R. B. Canright, ARPA; Maj. Gen Holger N. Toftoy, Aberdeen Proving Ground; Homer E. Newell Jr., NASA; Barnet Adelman, Space Technology Labs; and to Mrs. Iven C. Kincheloe Jr., who accepted the ARS Astronautics Award for her late husband. The dinner also saw presentation of the first annual ARS-Thiokol Award, to Fred Reardon Jr. of Princeton Univ., and of the ARS-Chrysler Corp. Student Award, which went to Thomas W. Godwin and Carl F. Lorenzo of Fenn College.

Fellow memberships announced at the banquet were presented at the luncheon the following day (in a painless ceremony M. C.'d to perfection by Kurt Stehling of NRL) to Brig. Gen. Homer Boushey; C. Stark Draper; Herbert Friedman; R. D. Gompertz; Robert A. Gross; Dan Kimball; A. K. Oppenheim; Adm. W. F. Raborn; Louis Ridenour; Abe Silverstein; Ernst Stuhlinger; and James W. Wheeler.

The Student Conference drew an attendance of some 175 students from 20 schools in all parts of the country, except the Far West. Student papers were presented at a morning session, with the afternoon session devoted to a lecture on steam rockets by former ARS President Robert C. Truax, on small, commercially available solid propellant rockets by G. Harry Stine of Model Missiles Inc., and films.

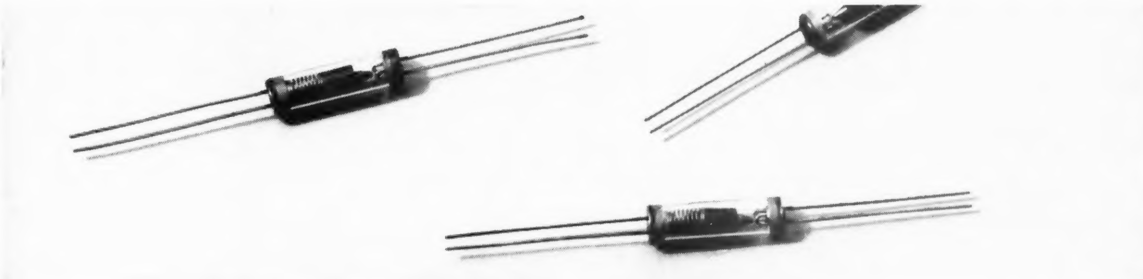
The Astronautical Exposition, one of the most attractive shows of its kind ever put on, featured sparkling exhibits by 56 different companies, many unveiled for the first time at the meeting. The 16,000 sq ft of floor space in two different areas were filled almost beyond capacity by the exhibits, which drew an attendance of several thousand during the three days the show was on.

Three other highlights of the meeting worthy of mention were the mammoth reception prior to the annual dinner, given, as last year, by Aerojet-General; the invaluable meeting roster printed and distributed by Rocketdyne; and the special Marketing Symposium, featuring a panel made up of Drs. Ramo and Gross, and Irwin Hersey, Astronautics Editor. Jim Harford was moderator.

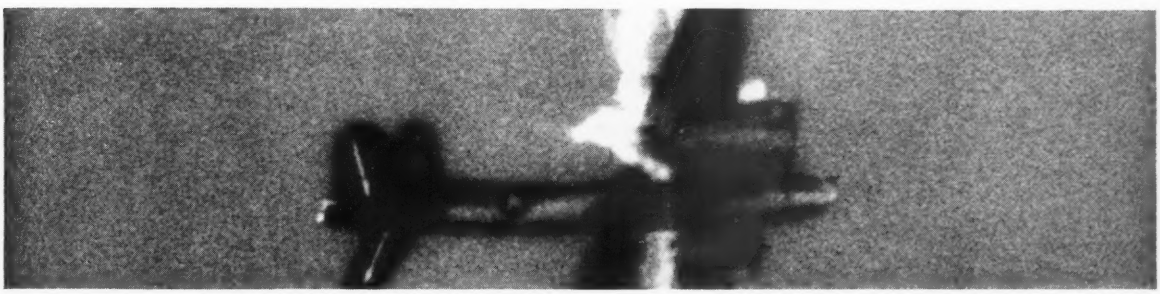
Pacific Missile Range Ready

The National Pacific Missile Range at Pt. Arguello, Calif., from which satellites can be safely launched into polar orbit from continental U. S., was expected to be basically ready for operations this month. The new facility will be managed from Pt. Mugu.

HUGHES THERMAL RELAYS



FOR RELIABILITY



IN GUIDED MISSILES

Hughes now makes commercially available a completely reliable single action switch. Used in the Falcon, field proven as a reliable missile, this Hughes relay is engineered to meet the most exacting of requirements.

With unusual speed of action, firing signal triggers the release of constrained contact...contact closes upon fixed contact point...switch circuit becomes permanently closed.

In a typical application, 3.0 volts DC applied to a firing circuit of 1.2 ohms fire within 0.3 seconds.

For additional information please write: Hughes Products Marketing Department, International Airport Station, Los Angeles 45, California.

SPECIFICATIONS

MECHANICAL—Body Size: Maximum diameter 0.252"; length .920". Total weight: Less than 0.1 oz.

ELECTRICAL—**Before Firing:** Insulation resistance is greater than 200 megohms. Minimum breakdown voltage 600 volts.

Firing: 2 volts minimum required. Actual voltage dependent upon closing time desired.

After Firing: Circuit resistance less than 0.3 ohm.

ALTITUDE—Any.

OPERATING TEMPERATURE: −55°C to +125°C.

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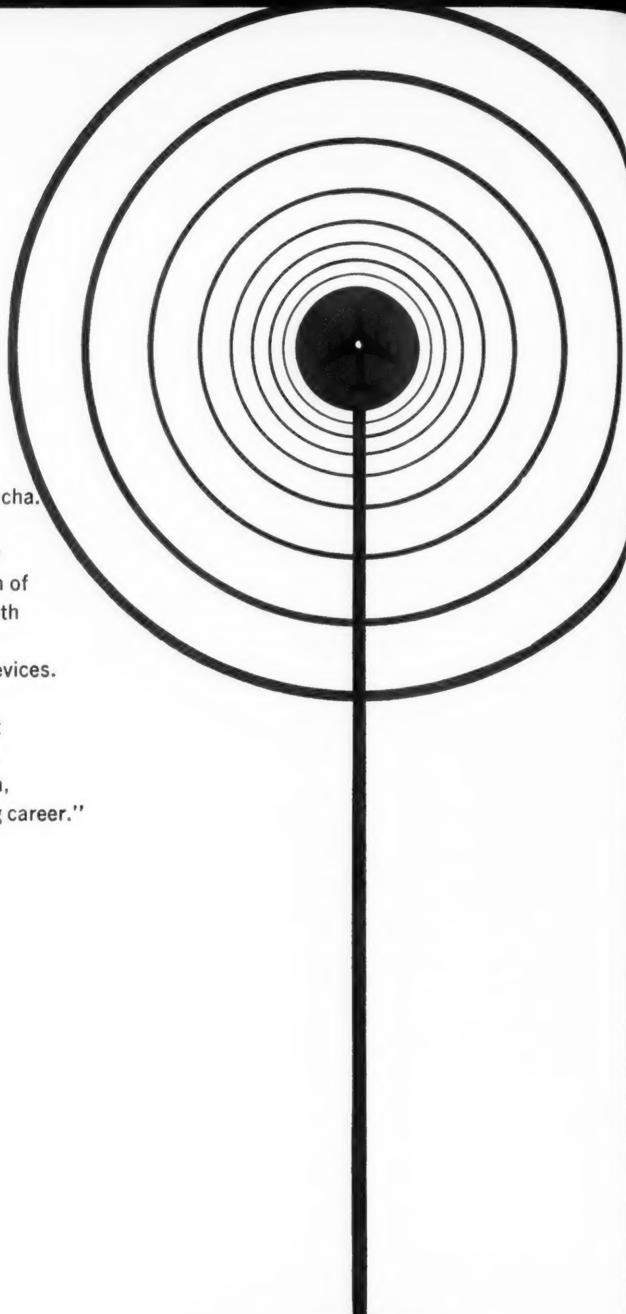


How a creative engineer can grow with IBM

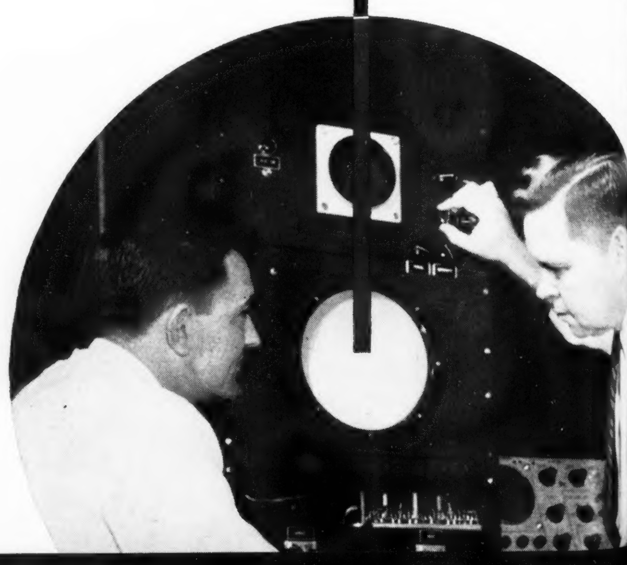
"Certainly my present assignment on the B-70 offers many growth opportunities," says Project Engineer Edward V. Zaucha. Designed to fly farther, faster and higher than any manned aircraft ever has before, the B-70 requires a completely new radar display system. "My responsibility includes the design of new cathode ray tube circuits plus system studies dealing with specific bomb-nav problems. These studies cover related equipment, such as the search radar and circuit indicator devices. In addition, I coordinate the development of storage tubes, high voltage power supplies and other equipment. A job that covers this much territory is a creative challenge. With IBM I have the opportunity to use all of my training; and in addition, I learn new things every day that will advance my engineering career."

Career opportunities in these areas . . .

- **Airborne digital & analog computers**
- **Ground support equipment**
- **Inertial guidance & missile systems**
- **Information and network theory**
- **Magnetic engineering**
- **Maintainability engineering**
- **Optics**
- **Radar electronics & systems**
- **Servomechanism design & analysis**
- **Theoretical design & analysis**
- **Transistor circuits**

Qualifications: B.S., M.S. or Ph.D. in Electrical or Mechanical Engineering, Physics, or Mathematics, and proven ability to assume a high degree of technical responsibility in your sphere of interest.

IBM is a recognized leader in the rapidly expanding electronic computer field. Its products are used for both commercial and military applications. Continuous growth means excellent advancement opportunities. The "small-group" approach assures recognition of individual merit. IBM provides excellent company benefits and salaries are commensurate with your abilities and experience.



Rocket Astronomy

(CONTINUED FROM PAGE 27)

about 3 deg wide—roughly what you see through a bundle of common drinking straws.

Such crude optics can be used because of the remarkable sensitivity of photon counters. The counters developed for rocket astronomy can detect almost every individual quantum of ultraviolet light that strikes them.

Four photon counters were mounted side by side with four viewing channels directed at angles of 105, 90, 82.5 and 75 deg to the long axis of the Aerobee-Hi. To obtain a scan of the sky, use was made of the spin and precession motions of the rocket. The photon counter and its hypodermic-needle telescope looked out through the skin of the rocket perpendicular to the long axis. As the rocket rose vertically, the spinning motion caused the "telescope" to sweep out a ring of the sky 3 deg wide, and, as the rocket yawed and precessed, the plane of this ring tilted relative to the stars. In this way, the combined spin and precession of the rocket served to sweep out a large view of the celestial sphere.

Throughout the flight, the photon-counter telescopes transmitted signals via radio telemetering to a ground station, where the complete history of the flight was recorded. Reconstructing a map of the sky from the telemetered data was like solving a jigsaw puzzle. The problem of determining at each instant of flight exactly where each detector was pointed is called the "aspect" problem. Visible-light photocells provided the clues for aspect orientation by detecting the bright stars and the air-glow horizons. The final solution put all the known stars in the telemetering record in exactly the observed sequence. After many months of laborious analysis, the aspect problem was solved with an accuracy of 1 deg.

When the first rocket astronomy experiment was planned, it was expected that the ultraviolet sky would differ from the visible sky in that certain stars would be much brighter in the ultraviolet than in the visible. The sun, for example, is a rather cold star classified as a yellow dwarf. Its color temperature is only 6000 K. By contrast, the blue-white stars have color temperatures as high as 50,000 K. These stars should look extremely bright in the far ultraviolet, whereas the sun should fade rapidly as the wavelength decreases.

The results of the rocket ultraviolet survey were very surprising. It appears that ultraviolet emission is an amazingly sensitive indicator of gase-

ous nebulosity. Where visible nebulosity is faintly observed in Virgo, a region of bright ultraviolet nebulosity more than 20 deg in diam was observed surrounding the hot (28,000 K) star Spica, even though no visible nebulosity can be seen with large optical telescopes. The ultraviolet glow about Spica was so intense that it masked the star itself, which is almost five times as hot as our sun. Within the narrow wavelength interval (about 100 A) to which the photon counters were sensitive, the ultraviolet flux from the region of Spica was 100,000 times as great as the total power radiated by the sun.

Detailed Contours Drawn

The nebulosities around Spica and Orion were scanned so many times that detailed contours like the one on page 26 could be drawn. The nebula around Spica is over 20 deg in diam, with an average surface brightness of 5×10^{-4}erg/cm^2/sec. There is no visible nebulosity in this region.

Although most of the observed radiation came from regions near the galactic plane, there were definite indications of sources at high galactic latitudes. The large map is a plot of the ultraviolet nebulae in galactic coordinates. The rocket view of the galaxy was confined to longitudes between 90 and 270 deg. Temperature contours of the radio background at 300 mc/s and the positions of radio stars are indicated for comparison.

Ultraviolet emissions are much more powerful than cosmic radio waves. The total radio frequency power over the entire observable spectrum is 10^{-11} watts per meter, which is about one-millionth of visible starlight. In the narrow ultraviolet band centered at 1300 A, the total power measured was about one-hundredth of visible starlight, or about 10,000 times as great as the total radio flux.

It is now well known that, among the 100 billion stars of our galaxy, there are enormous clouds of highly rarefied gases and fine dust. In parts of the galaxy, the amount of interstellar matter is comparable to the amount of matter in the stars. In fact, it is estimated that as much as half the matter in the universe is in the form of gas and dust. Stars are probably being continuously formed out of this interstellar matter by a steady condensation process. The study of interstellar matter is therefore of great interest to astrophysicists.

Only 25 years ago, our knowledge of gaseous nebulae was practically nil and classical astronomy was concerned entirely with the stars. Radio astronomy was born at the time when astrophysicists had just begun to appreciate the fact that our view of the galaxy was very much obscured by the the absorption of interstellar matter. The new ultraviolet map of the sky shows great concentrations of nebulosity in the plane of the galaxy in the same way that the distribution of cosmic radio intensity is related to the shape of the galaxy.

In spite of the similarities, however, radio astronomy and rocket ultraviolet astronomy should tell us very different things about the sources that give rise to them. Radio waves differ from light waves in that they may be generated by electric currents, whereas light and ultraviolet rays can be generated only by atomic and molecular processes. Lightning flashes, for example, produce radio noise at low frequencies. Mass motions of charged particles, called plasma oscillations, are believed to produce much of the cosmic radio emission, yet need not produce any optical effect. On the other hand, the kinetic energy of a gas can be readily transformed into ultraviolet radiation by the collisions of gas atoms or molecules.

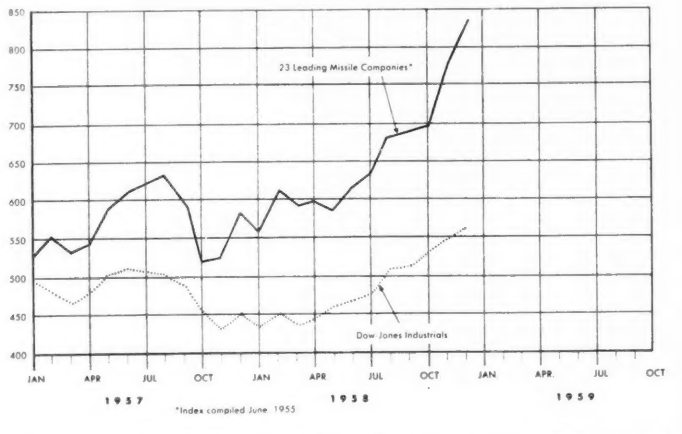
The first map derived from rocket astronomy may appear to be very crude, with its resolution of only 3 deg. But it should be recalled that the first radio maps published about 10 years ago had a resolution of only 10 or 20 deg.

It is entirely feasible to design simple mirror telescopes for use in rockets, and it is also possible to study a wide range of wavelenths. The future of rocket astronomy will see immediate developments in both directions. For its next attempt at ultraviolet astronomy, NRL is instrumenting an Aerobee-Hi rocket with 6-in. mirrors having a focal length of 10 in. At the foci of these mirrors will be placed detectors sensitive to narrow bands centered at 1100, 1300 and 1500 A.

Such experiments are the forerunners of much more elaborate experiments with large telescopes that will become feasible when 1000-lb payload satellites become available.

Missile Market

THE MARKET AT A GLANCE



	Dec. 1958	Nov. 1958	% Change	Dec. 1957	% Change
Dow-Jones Industrials	560	543	+3.1	450	+24.4
Missile Index	838	775	+8.1	578	+45.0

Final Approval Near for Standard Letter Symbols

A proposed list of American Standard Letter Symbols for Rocket Propulsion (ASA Y10) has been completed by Subcommittee 17 of the American Standards Assn. Sectional Committee on Letter Symbols and sent to all committee members for letter ballot vote.

The proposal was distributed to industry for comment through the medium of JET PROPULSION (November, 1955 issue, pages 634–645) and reprints from the magazine. These comments formed the basis for the April, 1958, redraft which was voted on.

People in the news

APPOINTMENTS

President Eisenhower has nominated **Maj. Gen. Bernard A. Schriever,** commander of the AF Ballistic Missiles Div., for the permanent rank of major general. The nomination will be submitted to the Senate this month.

Herbert L. Karsch, former project director of Aeronutronic Systems, Inc., has been named to the new position of planning director, Missiles Systems, for the Allison Div. of General Motors. **Capt. Martin W. Mason** (USN-Ret.), has joined the company as manager, liaison-Navy.

James M. Carter has joined Aerojet-General as coordinator of research activities; **Sol Skolnik** becomes technical specialist in the Chemical Div. while also serving as staff adviser to the Physical Chemistry Group; and **Ephraim M. Howard,** former senior staff engineer at Marquardt Aircraft Co., becomes technical specialist on special assignment to the manager of Applied Mechanics and Systems Div., Solid Rocket Plant. Howard temporarily is acting head of fluid mechanics and heat transfer in the Aerophysics Dept.

William M. Duke, a vice-president of Space Technology Laboratories, has been appointed director of the System Engineering Div.

Robert R. Wendt, former chief engineer, test operations, has been appointed assistant quality manager, Bendix Products Div.–Missiles. **Capt. Upton S. Brady** (USN-Ret.), former manager, missile guidance equipment, Farnsworth Electric Corp., joins the staff of general manager A. C. Omberg.

Neil McCormick has been upped from acting operations manager, Boeing Systems Management Office, to operations manager, while **K. K. McDaniel** becomes manager, Base Installation Dept.

S. S. Penner, professor of jet propulsion at CalTech, has been elected chairman for a two-year term of the Combustion and Propulsion Panel of the Advisory Group for Aeronautical Research and Development, NATO.

Autonetics, A Div. of North American Aviation, has established a centralized, fundamental and applied research activity to be headed by **Edgar L. Armi** as chief, research staff. New project engineer for reliability on the Minuteman weapon system is **W. J. West,** former staff specialist in systems analysis.

W. R. Clay, former director of engineering, R&D Section of Rheem Mfg., has been appointed assistant to the vice-president of engineering at Radioplane, A Div. of Northrop Aircraft.

Frank J. Lavacot, former head, Propulsion Systems Div., U.S. Naval Ordnance Test Station, has been appointed director of R&D at McCormick Selph Associates.

Harry G. Romig and **Donald J. Stewart** have joined Hoffman Laboratories Div. of Hoffman Electronics Corp. as director of reliability and technical assistant to the vice-president, respectively.

Merit Scott has joined Applied Sciences Div., Fairchild Engine and Airplane Corp., as scientific adviser to the staff.

General Electric's Missile and Space Vehicle Dept., has named the following managers in its Re-entry Vehicle Projects Operation: **R. L. Hammond,** program office, R&D; **R. A. Passman,** preliminary systems design; **I. M. Clausen,** SARV program; **R. J. Pierce,** systems evaluation; **H. Kimel,** projects technical support; **F. E. Rushlow,** business plans and operations; **W. Raithel,** advanced engineering; **J. P. May,** project engineering; and **O. E. Enders,** program manager, initial operating capability. **A. E. Buescher** and **S. H. Sigler** have been named Re-Entry Vehicle Systems engineer and administrative engineer, respectively.

The newly formed Defense Systems Dept. has appointed the following new section managers: **John K. Records,** to ground and information systems engineering; **Gen. Haywood S. Hansell,** to defense evaluation operation, Washington, D.C.; **Richard C. Raymond,** technical military planning operation, Santa Barbara, Calif.; **Curtis G. Talbot,** flight test operations, Schenectady, N.Y.; **Walter A. Hahn Jr.,** systems management research operations; **Donald L. Johnson,** manufacturing operations.

Gerald E. Kerr has been named manager of application engineering for Statham Instruments, Inc., while **Jess W. Burns** has been appointed director of technical services.

Kendall Clark has been appointed manager of military engineering at American Bosch Div., American Bosch Arma Corp.

L. Richard Bell Jr., chief design engineer of Sundstrand Turbo's engineering activities, will also serve as chief project engineer while **James A. Reeves,** former contract administrator, Atlas project, has been named project control manager of that program.

Gradon F. Willard succeeds **J. S. Bardin,** as manager of the Navy NiCal Plant under construction at Callery Chemical Co. Bardin has been upped to manager of production for Callery.

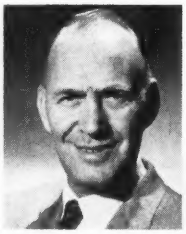
Ernest A. Keller has been named to the newly created post of staff scientist, Chicago Military Electronics Center of Motorola Inc.

Arthur W. Vance, former chief engineer, Astro-Electronic Products Div., Radio Corp. of America, has been named head of the newly formed Information Processing Research Dept., Hughes Aircraft.

Louis Weinberg, head of the communications and networks research section of Electronics Labs, Hughes Aircraft, has been re-appointed visiting professor of electrical engineering by CalTech, while **Robert W. Hellwarth,** has been re-appointed visiting lecturer in physics.

Armin F. Raebel has been promoted to chief experimental engineer at Solar Aircraft.

Karsch



Mason

Duke

Wendt

Brady

Lavacot

Ben E. Swanson has been named director of Kellogg Switchboard and Supply Co.'s newly formed Systems Engineering Div.

Joel S. Isenberg has been named technical director of Flight Sciences Laboratory, a new research and engineering organization. **Kenneth Pearce, Fred S. Roehrs,** and **Robert J. Whalen** have been appointed principal scientists.

Harry Wetzel Jr., vice-president and manager of AiResearch Mfg. Div., has been elected a board member of the parent company, The Garrett Corp.

Erwin Donath has been appointed technical vice-president of Applied Science Corp. of Princeton (ASCOP).

D. Wendell Fentress, vice-president of research and development, Flexonics Corp., has been named head of the newly established Flexonics Research Labs.

Merton R. Fallon has been named manager of field service engineering for Minneapolis-Honeywell's Aeronautical Div.

Martin Cooperstein, former supervisor, guidance and control section of Sylvania's Missile Systems Lab., has been named head of the Fire Control Dept.

G. Franklin Montgomery, adviser to the chief of the Electricity and Electronics Div., at the National Bureau of Standards, will also serve as chief, electronic instrumentation section.

George H. Found has joined the Engineering Div. of Arthur D. Little, Inc. as senior staff member.

Brig. Gen. H. F. Gregory (AF-Ret.) has been named vice-president and assistant to president G. R. Morrow of Midwestern Instruments, Inc. Gen. Gregory was former Commander of the AF Office of Scientic Research.

Carl E. Barnes, former director of central research, Minnesota Mining & Mfg. Co., has been elected vice-president for research. **John W. Copenhaver** succeeds Barnes.

Alfred W. Tucker, former manager, engineering operations, and chief of airframe design for North American Aviation's Columbus Div., has been named chief engineer, Cleveland Pneumatic Tool Co. Div., Cleveland Pneumatic Industries.

Gregory

Kleiman

A. K. Oppenheim, newly elected ARS director, has been promoted to professor of aeronautical sciences, Univ. of California at Berkeley.

Charles A. Naegeli Jr., has been named chief engineer for propellant-actuated devices, Missile Products Div. of Beckman & Whitley, Inc.

William W. Bumpus has been made manager of Consolidated Electrodynamics Corp. newly established government liaison office in Washington, D.C. **Henry S. Black** has been appointed director of the DataTape Div., succeeding **Philias H. Girouard** who becomes development coordinator for the corporation.

New vice-presidents elected at Douglas Aircraft are: **Elmer P. Wheaton,** director of missiles and space systems engineering; **Edward F. Burton,** director of transport aircraft systems engineering; and **Edward H. Heinemann,** director of combat aircraft systems engineering. Other appointments include: **Paul C. Swan,** chief project engineer for the Nike series, to manager of the newly organized Nike Weapon Systems office, Santa Monica Div.; **W. W. Benbow,** as chief project engineer for the Nike series; **S. L. McCroskey,** as project engineer, Nike Hercules; and **N. T. Weiler,** as assistant chief project engineer, Nike series.

Charles I. MacGuffie has been appointed manager of Air Reduction Sales Co.'s newly established Special Products Dept.

Robert Taggart, former technical administrator, Reed Research Inc., has formed the new research and development organization, Robert Taggart, Inc., to do work in the fields of aerodynamics, hydrodynamics, acoustics, and propulsion.

Joseph Kleiman has been named vice-president and general manager of Telecomputing's Whittaker Gyro Div., succeeding **Ward W. Beman** who has been upped to the newly created post of vice-president in charge of R&D for the corporation's six divisions and other associated companies.

Robert Kinkead, director of Republic Aviation's European Services, has been appointed assistant to the vice-president and sales manager.

Edward P. Hofstra, former manager of manufacturing engineering, Lockheed Missile Systems Van Nuys facility, has been named quality assurance manager there.

Paul E. Klopsteg has been appointed chairman of the National Academy of Sciences-National Research Council's Committee on Atmospheric Sciences. Three newly appointed members are **Fred L. Whipple,** chairman, Dept. of Astronomy, and Director, Smithsonian Astrophysical Observatory, Harvard Univ.; **Michael Ference Jr.,** chief scientist, Science Lab., Ford Motor Co.; and **John Tukey,** professor of mathematics, Princeton Univ.

Lee Arnold, former professor of civil engineering and engineering mechanics at Columbia Univ.'s School of Engineering, has been appointed professor and chairman of the Department of Aeronautical Engineering and director of the Daniel Guggenheim School of Aeronautics at New York Univ.'s College of Engineering.

HONORS

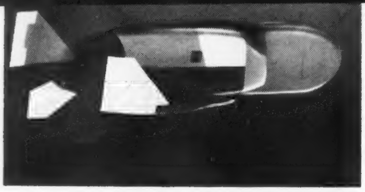
Glenn B. Warren, vice-president and consulting engineer of GE's Turbine Div., has been elected president of The American Society of Mechanical Engineers.

Malcolm R. Currie, co-head of the Electron Dynamics Dept. of Hughes Aircraft, has been named the "outstanding young electrical engineer of 1958" by Eta Kappa Nu, national honor society, for his technical contribution in the field of low-noise electron guns and backward wave oscillator development.

R. E. Gibson, a physical chemist, and director of the Applied Physics Lab., Johns Hopkins Univ., has been named as the first recipient of the Community Recognition Award of the Silver Spring, Md., Board of Trade, for "outstanding leadership in, and encouragement of scientific research and development."

DEATH

Hans R. Friedrich, assistant chief engineer of Convair-Astronautics and President of the ARS San Diego Section, died in a San Diego hospital on Dec. 6 at the age of 47. Dr. Friedrich, who played a leading role in the development of the V-2 at Peenemuende during WW II, came to U.S. at the end of the war to work, first at Ft. Bliss and later at Redstone Arsenal, where he helped develop the basic design for the Redstone. At Convair, he was an important figure in development of the Atlas. He had been stricken with a heart attack Nov. 28, shortly after returning to San Diego from New York, where he had been attending the ARS Annual Meeting, and only a few hours before the first full-course Atlas shot.



The GAM-72 Quail

This missile decoy, developed and manufactured by McDonnell Aircraft for the Air Force, has now been extensively test-launched from B-47 and B-52 aircraft at Holloman AF Base. A GE J-85 jet engine powers Quail.

Newton's Law

(CONTINUED FROM PAGE 19)

worked on the structure of clusters of galaxies.

Many of these, containing at least 10,000 member galaxies and recognizable on photos taken with the 48-in. Schmidt telescope, are spherically symmetrical. The richest among them seem remarkably similar structurally, regardless of distance from Earth. This structure, as it manifests itself primarily in the radial distribution of the member galaxies, as well as in the relative radial segregation of galaxies of different apparent brightness, can be predicted from statistical mechanical considerations and from knowledge of the law of interaction among galaxies.

If it is assumed, for example, that we are dealing with galaxies of the same mass; that the law of interaction is Newton's law; and that the cluster is in a statistically stationary state, then the number of galaxies per unit solid angle, and in dependence on the distance from the center of the cluster, is given by a function originally derived by the Swiss astrophysicist, R. Emden, in his classical work on gravitational gas spheres.

In actual spherical clusters, like those in Coma, Perseus, Hydra I and II, Corona Borealis and elsewhere, the member galaxies are, of course, not all of the same mass. It is likely, however, that, except near the outskirts of a cluster, the brightest galaxies are the most important, and that it is these galaxies which essentially determine the gravitational field and, therefore, the distribution of the galaxies within the cluster.

If Newton's law holds, then, a few hundred of the brightest members of a statistically stationary cluster of galaxies should be distributed according to an Emden function, such as it describes the density distribution in an isothermal gas sphere as a function of the distance from the center of the sphere.

Actually, from counts of galaxies in many clusters, it was possible to ascertain the following:

1. Very many of the rich clusters are spherically symmetrical, with axial fluctuations lying well within the limits expected for stationary agglomerations.
2. The 500 brightest galaxies of a cluster show a radial distribution which, within the uncertainties of observation and theoretically expected fluctuations, is adequately represented by an Emden function for an isothermal gas sphere.
3. There appears to be a marked segregation of bright and faint member galaxies in a cluster, an effect which must be expected to exist in stationary swarms.
4. The structural features discussed here are quantitatively the same for spherically symmetrical clusters at all distances which can be analyzed with the 200-in. telescope.

These four observations prove that Newton's law, with a fixed value for the universal gravitational constant, adequately describes the interactions between large masses, such as galaxies, *if these masses are not separated by distances greater than the radii R_{cl} of large clusters of galaxies.* On Hubble's old distance scale, R_{cl} is of the order of 3 million light years.

If this distance scale has to be revised as drastically as some of us believe, the validity of Newton's law, through counts of galaxies in clusters, may be considered established for separations of galaxies not greater than a few million light years and for distances of these galaxies not greater than a few billion light years.

Actually, these conclusions are strengthened by some additional results deriving from the principles of phenomenological and absolute morphology, which deal, respectively, with qualitative interrelations of phenomena and quantitative formulation of laws interrelating various phenomena.

Thus, in addition to counts of galaxy clusters, there are also fairly extensive data on velocity dispersion within the nearest clusters, as well as some information on the luminosity function of member galaxies and, most recently, information on the concentration of both intergalactic dust and neutral hydrogen within the clusters. Data of this type should accumulate in the near future and make it possible to derive absolute values for luminosities and masses of the various material constituents in galaxy clusters, thus providing a more accurate check on the range of validity of Newton's law.

Recently, however, some strong observational evidence has come to light which indicates, surprisingly enough, that the law breaks down when the interactions between clusters of galaxies, rather than galaxies, are examined.

Using the morphological approach, then, we must check all the possible theoretical conclusions which can be drawn with respect to the interactions of large masses separated by very great distances.

If we assume that Newton's law of gravitation is universally valid, we should expect to find certain phenomena related to the large-scale distribution of matter in the universe. Surprisingly, however, none of these phenomena have been found to exist, leading to the inescapable conclusion that the law breaks down at distances smaller than expected in any of the current cosmological theories.

The two major points here are:

1. If the law is universal, we should expect the clustering of galaxies to be unlimited. Actually, however, the largest spherically symmetrical clusters found among the 10,000 clusters searched are very similar, and all are of about the same size and population as the well-known clusters in Coma, Corona Borealis, and Hydra II. Thus, there exists a limit to the size and population of statistically stationary and geometrically well-organized clusters.
2. If the law is universal, we should also expect to find *clustering of clusters* of galaxies. Extended investigations have shown, however, that the phenomenon of symmetrical swarm foundation and agglomeration stops with the galaxies. While galaxies form clusters, the clusters do not in turn form clusters of clusters.

This nonexistence of clusters of clusters has been confirmed by a number of different investigations.

Clusters Distributed Uniformly

First, it is remarkable that the 100 nearest clusters are distributed in space with remarkable uniformity. There is no close pair or multiple system among them. In sharp contrast to this is the fact that there is hardly a single galaxy among the 100 nearest or brightest which is not bunched with other galaxies in groups of two, three or more.

Second, it has been clearly demonstrated that the 10,000 galaxy clusters which can be photographed with the Schmidt 48-in. telescope are distributed uniformly and randomly, both in breadth over the sky, as well as in actual depth of space, as if they were completely noninteracting objects. Although it appears at first glance that there are some fairly pronounced nonuniformities in the distribution of clusters which might be caused by clustering of clusters, it has been shown that these nonuniformities

are caused by the interference of clouds of intergalactic dust.

Third, among these 10,000 clusters, no bona fide double or multiple cluster consisting of globular or elliptical clusters has been found. This again is in sharp contrast with the behavior of globular and elliptical galaxies, which show a tendency to congregate in clusters of various sizes.

Fourth, if Newton's law were valid for separations of the interacting masses which are greater than 5 million light years on the old scale, we should expect nonuniformities in the large-scale distribution of both galaxies and clusters of galaxies, the fluctuations having dimensions of tens to hundreds of millions of light years and greater. No such fluctuations exist, inasmuch as all observational data show that clusters are distributed uniformly and randomly like noninteracting objects in a stationary universe.

Fifth, according to Newton's law, as we go to larger and larger masses, the velocity dispersion within the clusters they form increases. Thus, velocity dispersion for stars within a galaxy is of the order of 10 to 100 km/sec; among galaxies in small groups, 100 to 500 km/sec; and within large galaxy clusters, 500 to 3000 km/sec. If there existed any physical clusters of clusters of galaxies, the velocity dispersion expected on the basis of Newton's law would be of the order of 3000 to 10,000 km/sec. Actually, however, velocity dispersion among neighboring galaxy clusters is so small as to be observationally indistinguishable.

Newton's Law Breaks Down

As a result of these observations, we must conclude that Newton's law of gravitation seriously breaks down when (using Hubble's old distance scale, with the Coma clusters at, say, a distance of 45 million light years) the interacting masses are separated by distances greater than $D_{crit} = 5$ million light years, or 5×10^{24} cm.

Assuming that, for masses which are separated by distances equal to or greater than D_{crit}, the force of gravitation is really reduced to a small fraction of that predicted by Newton's law, we are faced with several serious consequences.

In the first place, the general theory of relativity in its present form will have to be abandoned. The theory is indeed based on field equations which, in the limit for weak fields, are adjusted to Newton's law. If, however, the law must be modified for weak fields, the same is true for the general theory of relativity.

In the second place, all conclusions about the evolution of the universe and its supposed expansion which derive from the general relativistic analysis of a number of cosmological models become untenable if Newton's law breaks down under the conditions stated above.

Suggestions have been made that some of the damage wrought to the general theory by these new findings might be repaired through the assumption of the existence of galaxies and clusters of galaxies which are composed of anti-matter, or contraterrene matter—that is, of negative protons and positive electrons. Also, the idea has been advanced that, with large masses distributed over large expanses of space, some shielding factors might have to be introduced into the field equations of the general theory, or that such shielding might actually be a consequence of these equations when applied to a multibody system.

For the present, however, I find it most profitable to proceed with the working hypothesis that bodies which are separated by distances greater than D_{crit} simply do not interact at all, and that Newton's "universal" law is not so universal as has been believed up until the present time.

It would be advisable to develop the consequences of this assumption and to test them observationally before indulging in idle speculation.

Space Navigation

(CONTINUED FROM PAGE 25)

wich Hour Angle of these bodies are also tabulated, even though they do not have fixed positions on the celestial sphere. Conversely, by knowing one's position, the true north azimuth of the line of sight to one of these bodies may be found. Also, by knowing one's position and having a true north azimuth reference, the line of sight to one of these bodies may be found.

As long as the space vehicle stays in the solar system, only negligible errors exist in angles measuring between stars. Small errors arise from not being at the center of the celestial sphere (on the Earth) and because of the finite velocity of light. But, measuring angles between stars alone (not including the sun) cannot give position information once the traveler gets out in the solar system. What is required is sightings of the stars relative to a "near object." Terrestrial navigation with celestial fixes sees the Earth as the near object—hence the need for a horizontal (Earth) reference.

What is more, errors in measuring angles between planets due to not being at the center of the celestial sphere and due to the finite velocity of light are not negligible. This is one fundamental difference—which we will not pursue further—between celestial navigation on or near Earth and celestial navigation in space.

Finally, a measure of altitude (distance from Earth) and a horizontal Earth reference are not available directly from celestial navigation on or near Earth, and must be obtained through external sources.

If altitude and a horizontal Earth reference are not available from external sources in space navigation, this discrepancy has to be taken care of by measurements on two near objects. This is the second fundamental difference between celestial navigation on Earth and in space.

Actually, it is possible to obtain altitude and a horizontal Earth reference in space navigation from radars and horizon scanners, respectively. In this case, space navigation using celestial fixes is similar to that described for terrestrial navigation. Such problems as refraction and deflection of rays of light under the action of mass attraction are common to all forms of celestial navigation and need not concern us here.

Knowing the positions of two near objects in the solar system, and knowing the angle between the line of sights from the vehicle to these near objects, the vehicle's position can be located on the surface, as shown on page 25. Any one of the following techniques allow reducing the possible positions of the vehicle to one point:

1. Taking sightings between the two near objects in question and at least two other near objects.

2. Making distance measurements between the vehicle and the two near objects in question. This reduces the possible positions of the vehicle to a circle. By using one other near object, three such circles are possible, and the possible position of the vehicle reduces to a point.

3. Taking sightings between the two near objects in question and at least three stars, not including the sun.

The third method has the advantages that only nonradiating instruments need be used and only two near objects are required. There is also the possibility that the two near objects and three stars can be selected so that their angular displacements from one another will be small, thus minimizing the astrodome problem.

Complicated as it is, space navigation, as we have mentioned, forms only part of the problem of midcourse guidance. Re-entry and landing guidance will be another problem—one to be faced to a limited extent in such programs as Dyna-Soar (Air Force Orbital Bomber).

Weather Reconnaissance

(CONTINUED FROM PAGE 33)

1000 ft. This was determined from study of cloud pictures taken by rockets. A resolution of 500–1000 ft is certainly attainable with present TV and optical systems, and would not require an exorbitant bandwidth in a radio link to the ground.

Cloud observations from a satellite could allow the synoptic meteorologist to view the entire weather pattern in a way that he can hardly achieve by present indirect methods. That is, since specific cloud families are associated with particular meteorological phenomena, a cloud picture of a large area of the world gives a knowledgeable person a crude but complete weather map.

There is a great deal more information that can be extracted from cloud photographs. Wind direction, for instance, can be estimated in several ways. First, present meteorological models relate certain weather to preceding or following clouds, which serve to orient weather with respect to the ground. Wind direction can then be approximated through a knowledge of the theoretical circulation associated with a given synoptic weather situation. Second, since cumulonimbus clouds extend from 1000 up to 40,000 ft, their slope becomes a good indication of wind shears. Third, cumulus clouds form on the lee side of mountains. Finally, the direction of movement of atmospheric pollutants, such as industrial gases, can indicate the direction of winds at low altitudes.

Temperatures can be estimated by starting with the statistical norm for the time of year, and then modifying this norm by observations of cloud systems, wind direction, and even forms of general cover (snow, etc.) that aid the analyst to decide whether the area under observation is being affected by relatively cold or warm air. Upper-air temperatures can be estimated in the same manner, clouds indicating the boundary between air masses (fronts). The slopes of vertically developed cloud forms also aid in determining the temperature gradient of the surrounding area.

No quantitative values of pressure are forthcoming from an analysis of observations of this kind; and it is virtually impossible to make even a quantitative estimate, other than whether the area is under the influence of a high or a low.

Given the ability to record and identify clouds, it appears possible to make a fair estimate of weather. But periodic observations must be made to give weather prediction a continuing, dynamic form. For most weather phenomena, the maximum allowable cycling time is about 24 hours. We must then ask: Can 24-hour continuity be established with satellite observations?

To answer this question, let's assume the location and movement of low-pressure systems constitute the most valuable pieces of weather information, and that low-pressure systems are characterized by associated cloud systems. We need two further simplifying assumptions—that the clouds associated with a cyclonic system cover an area at least 400 mi across and can be represented by a square configuration, and that a system can be detected if even a small part of its clouds come within viewing range. The latter becomes reasonable if we remember that there will be some measure of day-to-day synoptic continuity. These assumptions allow us to examine the probability of detecting low-pressure systems as a function of time.

Keeping in mind that the successive passes of a satellite will be evenly spaced in longitude, we can write an expression for the probability that any storm existing will be seen at least once a day: $P\phi = N(W_p + W_c)/D\phi$, where N is the number of satellite passes within a distance, $D\phi$, measured along a given latitude; ϕ is the latitude of the center of the storm system; W_p is the width of the viewing path; and W_c is the width of the cloud square. The probability, $P\phi$, has been computed for $W_c = 400$ mi and $W_p = 400$ mi, and is shown by the graph on page 33.

Storm Detection

As can be seen, the probability of detecting a 400-mi-wide storm anywhere in the U.S. is greater than about 60 per cent, increasing toward the latitude of tangency (in this case, 83 deg N). A curve representing a storm width of 100 mi has also been plotted on this graph. You can see the minimum probability decreases to approximately 35 per cent. This is not discouraging, however, because the average cyclonic storm system is at least 400 mi across, and some are as large as 1000 mi across.

The same graph also shows probability of detection with a path, W_p, equal to 1200 mi. This 1200-mi width can be achieved with the same satellite viewing system as that for the 300-mi high, 400-mi wide one by increasing the altitude of the satellite to approximately 1000 mi (a factor of three). This degrades resolution by a factor of three also.

On the basis of this analysis, then, it appears feasible to conduct weather

reconnaissance from a satellite in terms of contrast, resolution, area coverage and continuity.

As satellites, and our ability to control and keep track of them, improve, it seems certain that we can expect an equivalent improvement in the expected weather data. The improvement will probably be in the direction of more quantitative information on the atmosphere.

For example, if we can accurately determine the height, position and velocity of a satellite as a function of time, it appears feasible to determine the height of clouds viewed, which would be of some use to the meteorologist. This might be done as illustrated on page 33. At a time t_1, a vertical picture is taken of the earth's surface, and a cloud directly below the satellite is related to this vertical. At another time, t_2, a second vertical picture is taken which includes the same cloud. The angle off the vertical to this cloud in the second picture allows the height of the cloud to be calculated by some simple trigonometry involving the law of sines.

Widger and Touart and the Technical Panel for the IGY Earth Satellite Program have suggested other quantitative information that a sophisticated satellite could gather. Among these suggestions are:

1. Total moisture content. By measuring the intensity of reflected radiation at two adjacent wavelengths in the near infrared, one of which is not absorbed by water vapor and the other of which is partially absorbed, the total amount of water vapor in a column of the atmosphere in which there are no clouds can be determined.

2. Total ozone content. Utilizing somewhat different wavelengths than those for moisture, the total ozone content can be determined.

(Moisture and ozone content might also be measured by observing strong sources of radiation on the earth's surface at wavelengths of known water-vapor and ozone absorption.)

3. Temperature at or near the tropopause. By observing radiation in the 6-micron absorption band in the vertical, it would be possible to measure the radiation emitted by the top of the tropopause, and hence to map the effective temperature of that region.

4. Temperature at or near the top of the ozone layer. Similarly, measuring the emission at 9.6 microns would give the effective temperature in the top of the ozone layer, and would allow meteorologists to map temperature in a part of the atmosphere usually inaccessible to balloons.

5. Total radiation. The total infrared and solar radiation flux being absorbed, reflected and emitted by each part of the earth is of great theoretical importance, since it is the balance between these inputs and outputs which determines what is now only the roughly estimated heat budget of the atmosphere. This type of observation is relatively easy to make, and the means for it have already been developed for the IGY satellite program by Verner Suomi of the Univ. of Wisconsin.

6. Radar measurements. Radars operating at wavelengths of the order of 3–10 cm might possibly give information on precipitation areas.

It should also be possible to measure the variation in solar radiation reaching the earth's atmosphere, particularly in the ultraviolet and X-ray region, which cannot be observed from the ground. Measurement of solar radiation would be of more interest initially as a research experiment than as a day-to-day assistance in weather forecasting. When knowledge of the atmosphere and how it is influenced by energy-input variations improves, measurements such as variation of solar X-radiation, variation of heat input to the atmosphere (heat balance), etc., will indeed serve as forecasting tools.

Having a satellite that provides weather data does not guarantee usability of the data by the various meteorological services. The usefulness of a particular item of weather information decreases rapidly after it is obtained. For this reason, it is important to provide a mechanism for distributing satellite data as rapidly as possible in a usable form. An hour would be about the maximum delay that could be tolerated between gathering and delivering data to make it most useful.

A delay of this order suggests a rather elaborate pickup and relay system. One might visualize a "satellite weather data center" for extracting the maximum usable meteorological information and transmitting it immediately, and for composing picture mosaics to show overall cloud coverage, these, too, being transmitted without delay.

Rapid Data Dissemination

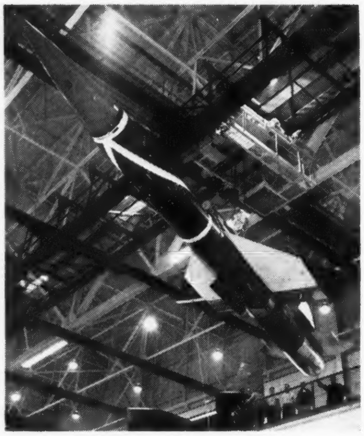
For a satellite to have maximum usability for weather coverage and forecasting, at least as much thought and effort will have to be put into the analysis and dissemination problem as into the design of the satellite itself.

In summary, it appears that satellites can make immediate useful additions to the weather data now being collected by the worldwide meteorological network. Satellite data would at first be mainly qualitative, concerned primarily with cloud types and patterns, but would become quantitative with the advent of more sophisticated vehicles. In addition to aiding in the forecasting of daily weather, future satellites should also aid in research leading to improved operational assistance from the weather services.

Most of the ideas suggested here have not been completely proved. Some theoretical work is presently being carried out by the Air Force and Rand Corp. The current IGY program will provide a preliminary test of some of the ideas through the Signal Engineering Labs cloud-cover experiment and the Univ. of Wisconsin's radiation-balance experiment.

Enough work has been done, however, to indicate clearly the desirability of satellites for weather reconnaissance. It is not inconceivable that the not-so-distant future will see satellites supplanting part of our present weather network.

Bomarcs for New York



This IM-99 Bomarc, shown being lowered from a production balcony at Boeing's Seattle factory, may wind up at the 300-acre $13 million launching base being erected adjacent to Suffolk County AF Base to protect the New York and Boston areas from air attack. Turnbull Inc., Cleveland, Ohio, designed the base, under Army C of E direction.

Inventions Wanted By the Armed Forces

The 1958 supplement to the basic 1957 listing of inventions wanted can be obtained free by writing the National Inventors Council, U.S. Dept. of Commerce, Washington 25, D.C.

One invention sought: A dumb satellite with a trailing wire or screen which acts as a scatter reflector similar to a natural meteor trail.

Holaday Named to Head Space Liaison Committee

William M. Holaday, Defense Dept. Director of Guided Missiles, has been named chairman of the Civilian-Military Liaison Committee established under the act creating NASA to resolve civilian and military disputes over the national space flight program.

Holaday will retain his DOD post until a Pentagon director of research and engineering is appointed. This position, established four months ago, has remained unfilled despite intensive efforts to recruit someone with the necessary qualifications.

Other members of the committee are as follows:

For NASA, Hugh L. Dryden, deputy administrator; Abe Silverstein, director of space development; Homer J. Stewart, director of program planning and evaluation; and Ira H. Abbott, assistant director for aerodynamics and flight mechanics research. Alternates are Marquis D. Wyatt, assistant director for space flight development, and Abe Hyatt, assistant director for propulsion research.

For DOD, Roy W. Johnson, ARPA chief; Maj. Gen. W. W. Dick, Army Special Weapons director; Vice Adm. R. B. Price, deputy chief of Naval Air Operations; and Maj. R. P. Swofford, assistant AF deputy chief of staff for development. Their alternates will be John B. Macauley, deputy assistant secretary of defense for research and engineering; Col. J. F. Smoller, Army deputy director of special weapons; Rear Adm. J. T. Hayward, assistant chief of naval operations for research and development; and Maj. Gen. M. C. Demler, AF R&D chief.

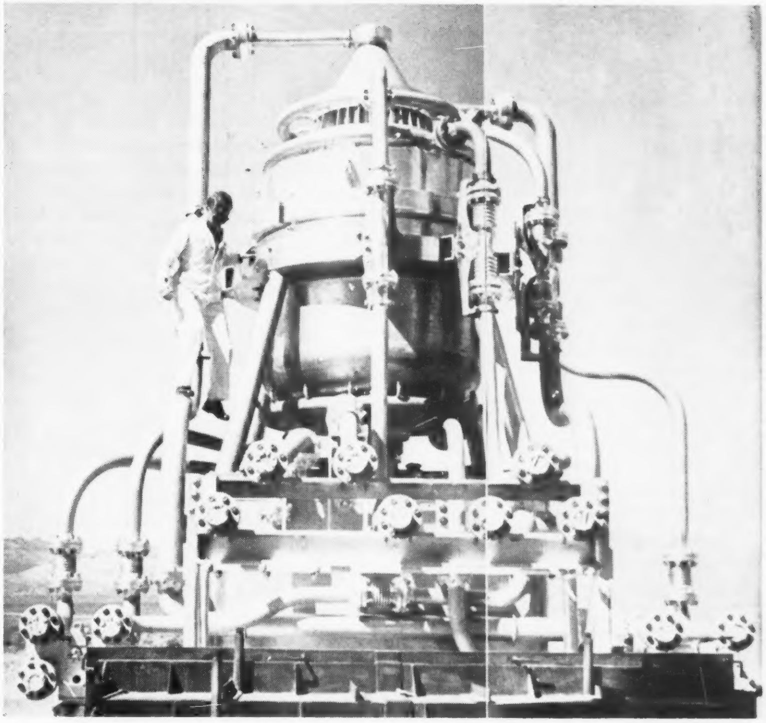
House Committee Urges International Astronautics

In a recent report, entitled "International Cooperation in the Exploration of Space," the House Select Committee on Astronautics and Space Exploration, headed by John W. McCormack (D., Mass.), proposed formation of an international astronautics and space organization composed of representatives of governments and scientific organizations. The report recommended that NASA take these steps: 1. Form permanent liaison facilities for mutual work with other countries; 2. Catalog the talents and proposed work of persons here and abroad; 3. Evaluate foreign proposals for space projects; and 4. Contract as it feels appropriate with groups here and abroad for studies, construction of equipment, and operations.

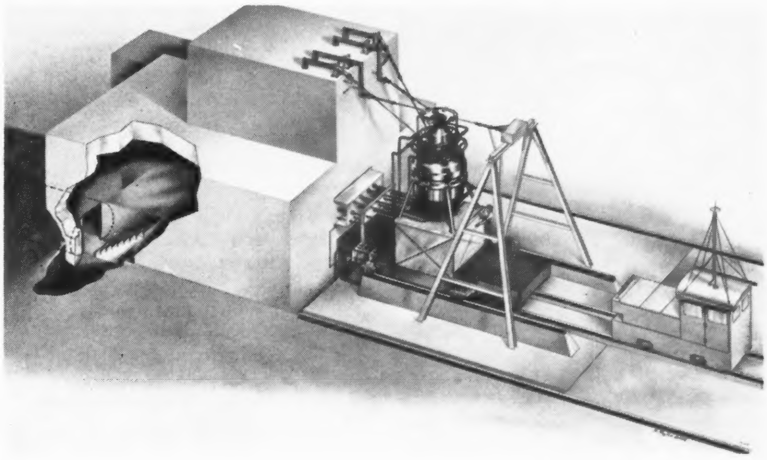
The committee also recommended that training facilities in the space sciences be expanded to keep education abreast of this country's plans for space, and it prompted Congress and the President to give continuing encouragement and financial support to work begun in the IGY.

The Committee emphasized that these steps should be taken in the context of an international organization, and should be regarded not merely as unilateral stopgap measures to allay enthusiasm for space flight and research, but as part of a continuing and growing program of international astronautics.

Kiwi-A Reactor and Test Stand



Above, first photo of Kiwi-A nuclear reactor for rocket propulsion, slated for testing at AEC Jackass Flats, Nev., test facility in near future. Artist's drawing below shows reactor in place on test stand, with prime mover (at right of drawing) which will remove it for study after the test.



Joint Venture

Arde Associates, makers and designers of motor metal parts, and Portland Copper and Tank Works have formed a third company, Arde-Portland Inc., to develop and manufacture metal parts for rocket motors.

In print

Guided Missiles, McGraw-Hill Book Co., New York, 575 pp., illustrated. $8.

As a pioneering treatment of pertinent fundamentals in one book, "Guided Missiles" is a credit to its sponsor—the U.S. Air Force—and to its publisher—McGraw-Hill. Originally written in 1955 as a manual for the training of AF technicians, it has now been published for public use. Presumably reflecting the fact that the manuscript was prepared at the taxpayer's expense, this book at $8 per copy, is a real bargain.

The book's purpose, quoted from a paragraph obviously directed at students, is "to inform you of the aerodynamics, propulsion, instrumentation, electronic control, and guidance systems involved in guided missiles. You will also learn of the capabilities of missiles, how they can be used, and what your job might be in a missile squadron."

So long as you approach it as a technician, rather than as a design engineer, you will find the book achieves this purpose.

Chapters carry the following titles: "The Story of Guided Missiles," "Aerodynamics of Guided Missiles," "Propulsion of Guided Missiles," "Physics Involved in Guided Missile Design," "Components of Guided Missile Control Systems," "Components of Guided Missile Guidance Systems," "Guided Missile Control Systems," "Trajectory Considerations of Guided Missiles," "Guided Missile Guidance Systems," "Guided Missile Tactics," and "Guided Missile Instrumentation." By striking the words "guided missiles" from all these titles, one of the book's defects can be illustrated, i.e., unnecessary detail, leading to a bulky encyclopedic volume.

Blue pencil editing of lengthy treatments of physical principles to be found in undergraduate textbooks and multiple circuit diagrams of a nonfundamental type would have improved the book. Newton's laws are explained in two separate places, on pages 50 and 91, while pages 517 and 518 provide a circuit diagram of a telemeter modulator unit of small use to a fundamentals-seeking airman. In both instances, however, the explanation is lucid, nonmathematical and beautifully illustrated—a situation characteristic of the entire book.

A background of high school mathematics, physics and chemistry, plus an interest in guided missiles, is the only equipment required of the reader. The discursive and illustrative techniques are modern and the material is complete when measured against its purpose. Unhappily, one finds himself using the table of contents as much as the index in trying to find what one wants; even using this method, this reviewer was unable to find an adequate discussion of electromagnetic propagation or what limits the range of a radar.

To illustrate the book's lucid style and technical approach, a representative paragraph is quoted. "As you know, random drift in a gyroscope is that drift caused by bearing friction and dynamic unbalance. This type of drift results in an unpredictable precession of the gyro. Apparent drift in a gyro is that drift which occurs because of the rotation of the earth. It is toward the elimination of the random drift that designers and manufacturers of gyros are now concentrating their utmost efforts. Until a few years ago, the most accurate gyros available had random errors of plus or minus 1 minute of arc per minute of time, or 1 degree per hour."

The most important thing about this book is that it supplies a wealth of primary guided missile information at a time when English-speaking peoples are much in need of it. Every day engineers are being diverted into the guided missile or space flight fields and members of the Armed Services are commencing to train for their use. The former will find that "Guided Missiles" provides a simplified "overlook" upon which he can base a more sophisticated education. The latter will find it quite adequate for his purpose—especially if he asks a few questions of the instructor!

—**Grayson Merrill**
Fairchild Guided Missiles Div.

High-Altitude and Sounding Rockets, a Symposium held at Cranfield, England, July 18–20, 1957, published jointly by the Royal Aeronautical Society and the British Interplanetary Society, London, 136 pp., illustrated. $5.

This large-format volume represents an important addition to the technical literature, not only because it assembles the 13 papers presented at the Cranfield Symposium, but also because it follows the British formula of including the discussions which followed the papers—and such discussions are often at least as interesting as the papers themselves, if not more so.

Subjects covered at the meeting ranged all the way from scientific applications of rockets and satellites, through propulsion and design problems of high-altitude rockets, recovery and re-entry of satellites, and instrumentation, telemetry and guidance, to sealed cabins and psychophysiological problems of manned flight.

Some of the papers, such as those by Karel J. Bossart of Convair-Astronautics, on "Design Problems of Large Rockets," and by Lt. Col. J. P. Henry, Chief, Biosciences Div., Directorate of Technical Operations, European Office, ARDC, on "Psychophysiological Hazards of Satellite Flight," have already come in for a good deal of discussion both here and abroad. Others, particularly those on "Future Developments in Rocket Propulsion Beyond the Atmosphere," by L. R. Shepherd, and on "Recovery After Re-Entry by the Use of Aerodynamic Lift," by W. F. Hilton, are worthy of the more widespread dissemination this volume will assure.

In fact, the high caliber of most of the papers presented at the symposium, which brought together top scientists and engineers from the UK, U.S. and Russia, is clearly indicated in the volume, although it must be noted that the time lag involved in its publication, as well as rapid developments in the field of rocket and satellite technology during the past 18 months, have dated some of the material to a certain extent. Also, some annoying typos have crept into the text. The BIS and RAS have nevertheless performed a valuable service in making the complete proceedings of the symposium available in this form—a form which might well serve as a model for other societies planning publications of a similar nature. —**I.H.**

BOOK NOTES

Ten Steps into Space (available from The Franklin Institute, Philadelphia 3, Pa., $4) is the printed version of the highly successful course in astronautics presented by the Institute last year with I. M. Levitt, director of the Fels Planetarium, as coordinator. While the format of the course (10 lectures by 10 different authorities) meant that not every subject could be covered in detail, the book's 10 chapters do a first-rate job of presenting the uninformed but educated layman with a rundown on the history and back-

ground of rocketry and space travel. The authors—Willy Ley, Kurt Stehling, H. W. Ritchey, Fred Singer, Paul Herget, Gerhard Heller, Krafft Ehricke, J. I. F. King, David G. Simons, and Dr. Levitt—cover their assigned subjects carefully and well, with the material ranging from nontechnical (Ley, Levitt) to quite technical (Ehricke), depending on the topic under discussion. Sum-up: Another valuable book for the newcomer to space flight, although he may find one or two of the sections heavy going.

Rockets and Satellites (508 pp., illustrated, Pergamon Press, $25) might be sub-titled the IGY rocket and satellite manual. Edited by Lloyd V. Berkner, IGY reporter on rockets and satellites, this bulky, large-format volume is made up of selected papers presented at various IGY meetings and elsewhere covering all aspects of the subject, and thus provides a valuable guide for those working in the field. Unfortunately, the volume was assembled during 1957, which means that coverage of the first earth satellites is scanty and confined to a special 25-page bibliography in the back of the book. The paucity of Russian material (certainly no fault of the editors) is another minor drawback. Nevertheless, as an over-all view of the proposed IGY program, the book (Vol. VI in Pergamon's IGY Annals series) is deserving of a place in any reference library.

Designed as an introductory text for students with one year of college mathematics, **Physics for Engineers and Scientists** by R. G. Fowler, professor of physics at the University of Oklahoma, and D. I. Meyer, assistant professor of physics at the University of Michigan (Allyn & Bacon, Boston, $8), treats in one volume of 546 pages classical mechanics; heat, light and sound; electricity; and magnetism. The authors have attempted to show the impact of atomic and molecular physics on this traditional grouping of subjects, and bring about a cohesive discussion for the student.

"A Day in the Life of a Supersonic Project Officer" by Lloyd Mallan (David McKay Co., 178 pages, $3.95) recounts a rather long day and night for Maj. Robert Goetz as he puts the all-weather Convair F-102A interceptor through its paces against a drone target bomber, a Q-2 Firebee and a mock night raider at the Air Proving Ground Command at Eglin AFB. The dramatic potential in the exacting and dangerous duties of an aircraft-evaluation test pilot and the manifold operations that back up his hours of mock combat show in some of the more than 100 photographs of Maj. Goetz, the aircraft, and various glimpses of life at the proving ground. But Mr. Mallan writes in a coy and superficially dramatic present tense (Example: "A genuine feeling of joy surges within him"), interlards the narrative with idle chatter and extraneous and trivial description, and unfortunately makes Maj. Goetz sound rather like Smilin' Jack.

—J.N.

RECEIVED

Weltraumfahrt, by O. W. Gail and W. Petri (150 pp., Hanns Reich Verlag, Müchen 23, Germany; no price listed). Fundamentals of Astronautics, Auf Deutsch.

The Air, by Edgar B. Schieldrop (256 pp., Philosophical Library Inc., New York 16, $12). A history of flight.

Electronic Avigation Engineering, by Peter C. Sandretto (772 pp., ITT, New York 4, $9.50).

Sampled-Data Control Systems, by Eliahu I. Jury (453 pages, John Wiley & Sons, New York, $16). Basic theory in sampled-data systems and allied fields.

Effect of Surface on the Behavior of Metals, (100 pp., Philosophical Library, New York, $10). Lectures delivered at the Institution of Metallurgists refresher course in 1957.

Liquids and Gases, by Alexander Efron (117 pp., John F. Rider Publisher, New York 11, $2.10). Paperbound basic science text.

Metallic Rectifiers and Crystal Diodes, by Theodore Conti (164 pp., John F. Rider Publisher, New York 11, $2.95). Useful basic information.

Basic Pulses, by I. Gottlieb (176 pp., John F. Rider Publisher, New York 11, $3.50). Practical application of pulse theory.

Compact Heat Exchangers, by W. M. Kays and A. L. London (156 pp., McGraw-Hill, New York 36, $6). Summary of Stanford Univ. work for ONR on heat-transfer surfaces.

Basic Research in the Air Force (38 pages, Air Research and Development Command—Attn: RDTRL—Andrews AFB, Washington 25, D.C.). Synopsis of AF R&D agencies and programs.

Looking at the Stars, by Michael W. Ovenden (192 pages, Philosophical Library, New York, 1958, $4.75). A carefully written description of the universe for young students by the vice-president of the British Astronomical Association. Illustrated.

The Presentation of Technical Information, by Reginald O. Kapp (145 pages, MacMillan, New York, 1948, $2.95). By the dean of the faculty of engineering of London University.

Transactions of Short Course and Conference on Automation and Computers, given at the Univ. of Texas in conjunction with the Society of Petroleum Engineers (Vol. 1, 209 pages; Vol. 2, 111 pages; Univ. of Austin, Tex.; no price listed). Interpretive and technical papers.

Basic Concepts of Information Retrieval, the first of a series of papers covering the research of John W. Mauchly, is available from any branch of Remington Rand.

Instant Rocketry

(CONTINUED FROM PAGE 29)

Rocketry has contributed to our knowledge of the solar spectrum by revealing powerful fluxes of X-rays and extreme ultraviolet light. These radiations create the ionospheric layers of the high atmosphere. Although giving us a picture of the variations in the ionizing radiations, rocketry has not yet shown positive locations of these sources on the sun. Are the ultraviolet and X-ray emissions concentrated in localized regions of the chromosphere or corona, and how are they related to visible phenomena in the solar atmosphere? What we need are photographs of the sun in X-rays and ultraviolet light. Such photographs will be obtainable when lengthy exposures become possible in satellites; but, in the meantime, an eclipse offers a means of crudely differentiating the emissions from portions of the sun's disk and corona, and also offers the possibility of scanning the emission from the limb of the sun up to heights of the order of 10,000 miles.

Ionospheric soundings with pulses of rf waves have shown that the ionosphere does not disappear completely at eclipse totality. Is this due to the sluggishness of recombination processes, or to a residual ionizing flux capable of bypassing the occulting edge of the moon? If there is such a residual flux coming from coronal heights in the solar atmosphere beyond the border of the visible disk, is it composed of X-ray or ultraviolet radiation?

These are two questions that rocket astronomy is capable of answering. Furthermore, radio soundings seem to indicate abrupt discontinuities in the rate of decline or recovery of the ionospheric electron density as the eclipse progresses, that are identifiable with localized sunspot regions. Here again, rocket measurements during an eclipse could indicate the variation in intensities of ionizing radiations originating in such active solar regions.

As the eclipse progresses, it is possible to measure the contributions of sunspot regions as they are covered or uncovered. During totality, the photosphere is completely covered and any residual radiation must come from the outermost layers of the chromosphere and the corona. If a rocket is in the air for a couple of minutes leading up to second contact and for a corresponding interval just after third contact, its detectors should see the variation of emission with altitude above the limb up to the top of the chromosphere and perhaps into the inner corona.

The Nike-ASP rocket combination selected for the experiment had undergone a series of five tests shoots from San Nicolas Island during the month of July and appeared well-suited to meet the requirements of the eclipse experiment. The ASP rocket, manufactured by Cooper Development Corp., contains a high-performance propellant having a specific impulse in excess of 200 lb-sec per lb and a total impulse of 31,000 lb-sec. It is 107 in. long, $6^1/_2$ in. in diam and weighs 210 lb excluding the weight of the instrumentation section, nose cone, and thrust skirt. These latter items totaled 75 lb. The Nike stage was a standard Nike I, 16.5 in. in diam and almost 12 ft long, weighing close to 1300 lb with fins and coupling.

The ASP is coupled to the Nike rigidly by means of a separation ring fabricated from ductile cast iron. The Nike booster burns for about 3 sec, in which time it carries the ASP to a height of about 1 mile. When the thrust of the Nike booster begins to decrease, an acceleration switch ignites two blast caps which break the separation ring into halves, thereby freeing the ASP. At approximately 22 sec, the ASP has coasted to a height of 50,000 ft, where barometric pressure switches close the firing circuit. The ASP burns for 6 sec and reaches an altitude of 80,000 ft and a velocity in excess of 7000 fps at burnout. It then coasts to a peak altitude of 800,000 ft with its 75-lb payload and falls back to earth after a total flight time of 8 min.

X-rays Measured

The instrumentation units for the rockets were equipped with detectors to measure X-rays in two wavelengths bands, 8–18 A and 44–60 A and Lyman-α emission of hydrogen in the ultraviolet at 1216 A. Photocell units were included to permit determination of rocket aspect throughout flight. Bendix FM-FM telemetering was employed, using frequencies of 228.5 and 219.5 mc/sec at 2 watts power output with four subcarrier channels. Telemetered signals were received by means of antennas mounted in the nozzles of pairs of 3-in. guns which could be trained to follow the flights of the rockets. Tape and oscillograph recordings were made in the NRL trailer, housed forward in the well-deck.

A shipboard rocket operation introduces certain difficulties. First of these is the effect of roll. To avoid azimuthal deviations in launching direction, it was necessary to fire when the ship was horizontal. This was accomplished by means of a gyro-stabilizer which delayed the firing sig-

nal until the ship was horizontal within $\pm 1/4$ deg. Since the rockets could not be safely handled in a rough sea, all mounting work was accomplished while the ship was docked in Samoa. As a result, the rockets were exposed to weather for six days before firing, and suitable waterproofings had to be devised to keep the igniter circuits dry.

Instrumentation sections were installed the day before the eclipse and protected by waterproof sleeves of vinyl plastic which were removed shortly before eclipse time. The rigid coupling between the Nike booster and the ASP was essential to withstand the stresses imposed by the pitching and rolling of the ship. Finally, expert navigation was required to locate the ship at the planned position 40 miles from Pukapuka, beyond radar range, at exactly the proper time.

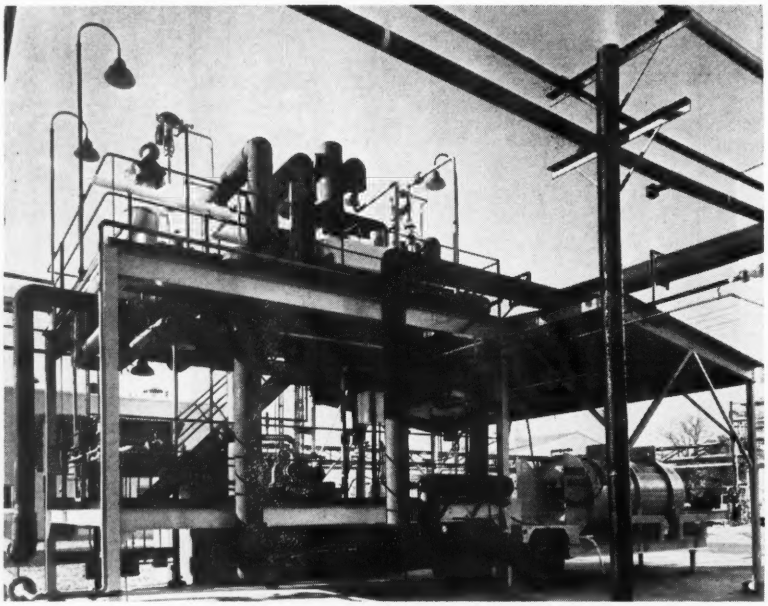
It was originally planned to launch two rockets for test purposes and background data on Sept. 28 and Oct. 1 and to launch six rockets on Oct. 12 during the eclipse. Two of the six eclipse rockets were to be in the air during totality and the remaining four were to be distributed so as to observe portions of the disk exposed before second contact and after third contact.

On the day of the eclipse, the distribution of visible activity on the disk of the sun was as illustrated in the solar disk drawing on page 29. It was decided to launch the first rocket about 10 min before second contact to expose a crescent on the east limb containing a number of sunspots. The second and third rockets were to be fired during totality. Shortly after third contact, the fourth rocket was to be launched so as to measure radiation from a crescent of the disk on the west limb. This portion was almost clear of activity except for prominence. The fifth and sixth shots were to follow the fourth at 10-min intervals.

Angle Was Important

The rockets were mounted on fixed launchers spaced in a pattern about the helicopter deck, allowing about 20 ft between rockets. To send the rockets off the stern of the ship, the launchers were inclined at an angle of 82 deg to the deck. Since rocket measurements were to be made at ionospheric altitudes, it was necessary to shoot from outside the ground level shadow. At eclipse time the ship was headed on a course of 115 deg 40 min northeast of Pukapuka at a position approximately 10 deg 21 min South, 165 deg 28.8 min West. The totality rockets were launched at an azimuthal angle of 295 deg so as to enter the eclipse shadow cone from the east at

Liquid Fluorine on the Road



At Allied Chemical's new Metropolis plant, liquid fluorine is dock-loaded into a truck trailer refrigerated with liquid nitrogen.

Allied Chemical's General Chemical Div., which recently began large-scale production of fluorine at its new facilities in Metropolis, Ill., as the initial step toward producing uranium hexafluoride this year for the atomic energy program, will ship bulk lots of liquid fluorine to rocket development centers in a fleet of truck trailers like the one shown at the right in this photo of a loading stand. Allied began such shipments from its Baton Rouge, La., facilities three years ago, at which time fluorine was shipped as a gas in 6-lb lots in 200-lb cylinders, a procedure which prevented any large commercial use of this powerful oxidizer. Fluorine is under intensive study as a propellant.

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an altitude of about 120 miles. Assuming ideal performance, the rockets would reach 150 miles altitude inside the shadow cone and then pass out of the cone on the west side as they fell back toward the ocean.

On eclipse day, the sky was overcast. At 7 a.m., large tropical thunderheads and cumulus clouds formed toward the southeast. Rain squalls hit the ship at 7:25 but the sky cleared considerably 15 min later. Plastic bags protecting the instrumentation sections were removed at 7:45 and the rockets were armed. The first four shoots went off as scheduled at 8:32:06, 8:42:03, 8:43:18, and 8:52:49.

Trouble Crops Up

Trouble arose when the time came to fire the fifth rocket. When the signal was sent to turn on the instrumentation, nothing happened. The blast of the first four shoots had apparently loosened the external pullaway plug carrying the starting signal to the rocket. An attempt to start the sixth rocket revealed a similar open circuit. While everyone watched with bated breath, Don Brousseau of the NRL group ran from the telemetering trailer in the well-deck up the ladders to the helicopter deck, climbed the rocket and re-inserted the loose plug. He then raced for the protection of the nearest gun tub. As he huddled behind the protective steel armor plate, the fifth rocket was fired at 9:10:09, 8 min later than originally planned. Because of this delay, the fifth rocket launching coincided with the time originally planned for the last rocket. There seemed little to be gained by firing the sixth rocket late in the final phase of the eclipse and the decision was made to hold it for a background measurement on the following day.

Preliminary examination of the telemetering records showed that the rockets reached peak altitudes of 139, 148, 152, 150, and 55 miles. The Lyman-α radiation appeared to follow the uneclipsed area of the disk very closely and almost disappeared within 10 sec as the rockets entered totality. In strong contrast, the flux of 50 A X-rays persisted throughout totality. Measurements before second and third contacts showed great limb-brightening in X-rays. The X-ray emission strongly resembled the kind of intensity distribution observed in radio decimeter wave measurements. The sun appears to be ringed by a bright X-ray halo.

Got Only 7 Deg to Sun

In the totality shoots, an attempt was made to scan the region about the sun in Lyman-α with an angular resolution of about 3 deg of arc. Unfortunately, the two totality rockets were very stable and neither developed enough yaw to scan closer than 7 deg to the sun. At that distance, some Lyman-α signal was evident in the record but the quantitative intensity evaluation will require careful data analysis. The aspect indicators used in the totality shoots were photomultiplier tubes which viewed the sky through gun-sight type reticles. The photomultipliers which were set to receive a flux equal to half of full moon in the visible were heavily overexposed. It appeared that the airglow in the totality cone remained very high and was responsible for saturating the photomultiplier response.

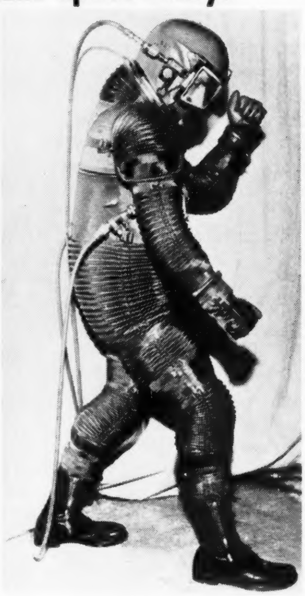
Detailed analysis of the telemetering records should yield quantitative information on the residual flux of X-rays at totality. Any asymmetry related to the sunspot distribution on the east limb, as compared to the absence of sunspots on the west limb, should be apparent in data recorded in the first and fourth shots.

The degree of success achieved in this first attempt to apply rocket astronomy to the study of a solar eclipse should encourage more diversified measurements in future eclipses. It would be interesting to compare the residual X-ray flux measured at the minimum of the solar cycle with the flux which was observed at maximum in this year's eclipse. It is well known that the corona assumes a more or less symmetrical shape near maximum, but takes the form of long equatorial streamers at minimum. The unexpectedly intense airglow at totality would be another interesting phenomenon to scan in time and geometry from rocket altitude.

An unexpected bonus was granted the experimenters when the last rocket was fired on Oct. 13. Entirely unsuspected at the time of firing, a class-

2 plus flare was in progress during the shot, which reached altitude shortly after the peak flare period recorded on the island. The rocket performed exceptionally well and good data were received on X-ray fluxes in the 8–18 A and 44–60 A bands as well as Lyman-α. The latter showed no significant variation, but the X-ray fluxes were strongly enhanced.

Sealed Plant Will Make Space Alloys



Navy BuAer will have missile and space-vehicle parts of refractory and high-temperature metals produced in a sealed argon-filled plant now being built by Universal Cyclops Steel Corp. at Bridgeville, Pa. Plant operators will wear suits—similar to the one shown here—which will supply air, remove carbon dioxide, and provide protection against ultraviolet and infrared radiation.

Redstone Missile Through Testing

The Army's test program for the Redstone missile concluded in November with a perfect 250-mile shot from Canaveral, the 34th successful firing in 37 tries over the past two years.

Atlas Missilemen Training

The Air Force, with technical service from GE's Defense Systems Dept., has begun training the first combat crews and AF instructors at Vandenberg AF Base, Calif., for the Atlas ICBM.

Mars

(CONTINUED FROM PAGE 30)

tation were the sites of dried-up seas. He overlooked the fact that such areas would be sterile with salt and possibly appear whitish if they were not too badly covered with reddish dust from adjacent deserts. Moreover, if Mars ever had seas in the past, it would have had rain and water erosion, which would have produced a visible dendritic drainage system instead of the canals.

But less romantic eyes than Lowell's turned to Mars. Astronomers have since given a fair description of the atmosphere and climate of Mars; and we will suggest, further on in our discussion, an explanation of the larger structure of the planet.

First, there was strong evidence for a Martian atmosphere, if not for seas. The polar caps shrink during the planet's spring and summer. While one cap melts and evaporates, the cap in the opposite hemisphere reforms by successive deposits of frost. The transport of this vapor requires a permanent atmosphere.

The remarkable clearness of the markings and their colors in the central part of the Martian disk indicates that the atmosphere is very thin. But it does affect our views of Mars. Halfway from the center of the disk to the limb, the colors of the surface markings begin to lose vividness; and especially noticeable is the progressive fading of the rich reddish-ochre desert areas into filmy whitishness toward the limb. The density of Mar's atmosphere near the ground is estimated to be only one-tenth or less than that of Earth's near sea level. Occasionally, clouds and haze obscure the surface of Mars, but far less than they do on Earth.

After Lowell, astronomers attempted to analyze the Martian atmosphere with powerful spectrographs attached to telescopes. No trace of free oxygen could be found and only doubtful indications of water vapor. The nitrogen lines are in the ultraviolet beyond our reach because of the ozone absorption in the Earth's atmosphere. But since nitrogen is an inert gas, we can reasonably assume that it makes up the bulk of Martian air. There is carbon dioxide and probably also some argon.

If Mars ever did have free oxygen in its atmosphere, what happened to it? A molecule of oxygen is relatively heavy and very little should have escaped into space. It is generally thought that oxygen combined with metals, principally iron and aluminum, to form part of the crust of Mars. Spectrographic studies suggest the

formation of a mineral like felsite. But it seems unlikely that the problem of Martian surface texture and minerals will yield easily to spectral and polarimetric analysis. The final answer can only come from an actual manned landing on Mars.

What has been deduced of the climate of Mars? The distance of Mars from the sun varies from 128 million miles at perihelion to 154 million at aphelion. This causes a difference in solar energy received of 53 and 36 per cent, respectively, of what the Earth receives. The poles of Mars are so tilted that the summer solstice of its southern hemisphere occurs near perihelion; whereas, summer solstice of its northern hemisphere occurs near aphelion. Consequently, the seasons of Mars are quite unequal in length.

The northern summers are 183 of our days (177 Martian days) and chilly; radiometric measurements indicate that mid-day temperatures scarcely rise more than a few degrees above the freezing point of water. The southern summers are 158 of our day's, but warmer; the maximum temperature shortly after noon is about 70 F. A fringe of the subantarctic zone possibly may not freeze at night at the time of summer solstice. Otherwise, the temperature drops far below freezing at night, even in the Martian tropics. The diurnal range of temperature is about 200 F over most of Mars.

Climate Has Profound Effect

The difference in the climates of the northern and southern hemispheres has profound effects on visible phenomena. In the southern hemisphere, with its warmer summers, the maria are vividly green at times. They undergo about the fullest range in seasonal colors, from green to bluish-grey and brown. The northern maria exhibit very little green, a neutral tint being more characteristic.

Also, the north polar cap behaves differently than its southern counterpart. Both present vast expanses of white when their respective poles become tipped toward the sun in the early spring seasons. Since the orbit of Mars is exterior to the Earth's, it means that what is tipped toward the sun is also, more or less, tipped toward us for view. Accordingly, there is a seasonal displacement of the markings northward and southward on the Martian disk.

The north polar cap is exactly centered on the north geographical pole. It is quite round in shape and uniform in whiteness. At maximum, it extends down to the 55th deg parallel. When the gradual spring shrinkage is well

under way, a dark-bluish band surrounds the edge, and thence retreats with the cap, getting wider as the season progresses. Lowell interpreted this band as free water in a temporary narrow polar sea. But it seems more likely that this dark-bluish band is wet ground rendered bluish by Martian atmospheric haze.

Various facts, such as shrinkage rate, the thin atmosphere and available solar energy, indicate that the snow cap can hardly be more than a few inches in depth. The water content could not be more than a few tenths of an inch. Since there are no visible breaks in the dark polar band, it would be asking too much to expect the entire polar region to be so perfectly flat and level.

Seasonal Changes

By the time the north polar cap shrinks to a diameter of about 25 deg in the middle of Martian May, the arctic atmosphere becomes hazy. A translucent vapor hood extends over the entire polar zone—hundreds of miles beyond the dark band, which can be seen faintly thru the haze. This phenomenon occurs every Martian year at the same seasonal date. Apparently not much evaporating water is required to saturate the cold, thin Martian air.

In Martian June, the haze gradually disappears, with some brief fluctuations. The pure white of the cap again appears but the diameter is less than 8 deg across. One major rift occurs in the cap when it nears minimum size, due to the invasion of a canal. It appears exactly in the same geographical position each Martian year, and it therefore represents a permanent feature of the landscape.

The north polar cap never disappears completely, remaining 5 or 6 deg across for several weeks. Four of our months after the summer solstice, thin depositions of frost begin to occur in large patches in high northern latitudes. These increase in frequency and intensity. The polar caps appear to reform through a succession of frost deposits—not by snowstorms.

The south polar cap is the larger, at maximum extending to an average latitude of about 42 deg. It suffers a prominent dent in the Hellespontus Depressio vicinity, where it is limited to the 50 deg parallel. Thus, we have an indication that the polar cap limit at maximum size is due to temperature, particularly the noontime frostline within which the frost can steadily accumulate.

The noontime frostline would be expected to reach to a lower latitude during the antarctic night when the planet is at aphelion, which explains why the south cap is larger. It is not unusual to see ephemeral extensions into lower latitudes toward the morning and evening limbs of the disk, but melting or sublimating back to higher latitude in the noon portion of the planet, then reforming in the late Martian afternoon. This phenomenon, of course, occurs when the antarctic region is lost in the polar night.

With the coming, near perihelion, of the southern hemisphere summer, the polar cap recedes rapidly. The dark border does not appear blue, perhaps because it is too narrow for us to perceive its color. The narrowness may be attributed to the ground not staying wet as long because of the warmer temperature. Several major rifts occur while the cap is still large. These rifts widen, finally breaking the cap up into several unequal pieces, which are referred to as the Mountains of Mitchell. Seldom does a polar haze set in, meaning that the warmer air is able to absorb all of the melted and evaporated moisture. However, a widespread south polar "haze" did occur in September, 1956.

Several observers have attributed the great southern obscuration in 1956 to dust. For several days, that entire area of the planet was as featureless as Venus. Even the brilliant white south polar cap remnant was not visible. Then the haze began to thin and markings gradually became more visible. The cap emerged as white as before. If dust in atmospheric suspension was thick enough to hide the surface markings, then the cap should have appeared conspicuously dirty when the dust settled out. Neither was there evidence of fresh-fallen snow or frost to cover up a dirty cap. When frost deposits occur, they are never limited to the cap remnant area. Not in fifty years of record has such an extraordinary event as this occurred. What happened?

In contrast to the north polar cap, the intensity of the south polar cap is not uniformly white in the peripheral areas when it is large. Some portions exhibit a duller lustre, as if the ground was slightly showing through in places. Indeed, its larger area may be at the expense of thickness. Accordingly, there would be more square miles of air contact to distribute the water vapor. It is interesting to note that the extent of the great southern obscuration in 1956 nearly coincided with the maximum recorded size of the cap. But the cause of this "haze" is yet to be explained adequately.

Life on Mars?

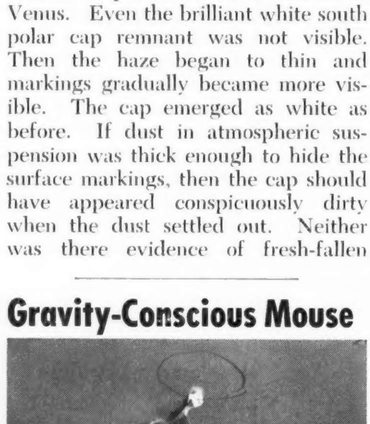
Matching this geophysical puzzle in interest are the old questions, What kind of life does Mars hold, and what are its canals?

As to life, new spectrographic evidence makes it appear likely that there is organic matter on the surface of Mars, covering perhaps three-eighths of its surface sufficiently to prevent us from seeing clearly the color of the soil. As Mars has little water, the only moisture being thin vapor diffused into the atmosphere from the polar caps during its spring and summer, we would expect any carbon-cycle vegetation on Mars to absorb water from the atmosphere to live.

This suggests "lichenlike" organisms. But, as Frank Salisbury of Colorado State Univ. points out, lichens, as we know them, do not exhibit color changes with changes of seasons—a pronounced event on Mars; they are very slow growing, and consequently hard to reconcile with some of the sudden and extensive temporary darkening, such as occurred over an area the size of Texas about 1700 miles northeast of the Syrtis Major in 1954; and they are a flat life form, which is not consistent with the observed re-emergence of the Martian dark areas in a relatively short time after being covered by yellow dust.

A vegetable life like that on Earth must, then, be highly specialized on Mars; or Mars harbors unknown life, a parabiology, as Salisbury calls it. We know the polar caps are water. Gerard Kuiper of McDonald Observatory has shown the atmosphere of Mars to contain 1.8 times the carbon dioxide of our atmosphere. Hubertus Strughold has discussed at length some very significant factors in cell physiology under the severe conditions of

Gravity-Conscious Mouse



With the aid of magnetic shoes, this black mouse walks upside down on the wall of a centrifuge for study of weightless and high-g reaction at the Navy School of Aviation Medicine, Pensacola, Fla.

Mars. The ingredients for a life and a photosynthesis within our imagining are definitely present on Mars.

Another important factor for life processes as we know them is protection against the lethal ultraviolet radiation from the sun. On Earth, Nature provides this protection in the form of an ozone layer, which exists between 20 and 30 miles above the ground. Dr. Kuiper found no traces of ozone on Mars. Neither did he find any sulphur dioxide, which also can absorb ultraviolet.

Photographs taken through filters which transmit violet and ultraviolet light only cannot penetrate the Martian atmosphere. Even in blue light, the photographs do not normally record surface markings. These wave lengths are intensely scattered, thus indicating that the Martian sky is dark blue in color. However, for a week or so, at certain opposition times, the Martian atmosphere suddenly becomes partly transparent to blue light, and surface markings are translucently recorded as "blue clearings." Two explanations have been suggested for this phenomenon.

Normally, the southern maria range from green to blue in color. The long dark sash, Sabaeus Sinus, running east to west only a few degrees south of the equator, is habitually bluish-green. Amazingly, when a "blue clearing" occurred in 1954, this marking—including the famous Dawe's Forked Bay at the west end, altogether some 2000 miles long—suddenly turned to bright lavender or perhaps magenta! The other maria did not. Why? Can vegetation inhabiting this area shield itself by changing pigment to reflect away a sudden influx of lethal radiation?

The Syrtis Major, the principal dark marking on Mars, also undergoes some very strange metamorphoses in color. The north half is habitually of a deep blue color, while the southern half is grey-green to blue-green or sometimes a vivid green. I remember one opposition when the whole marking became intensely black—totally devoid of any color! In the absence of oxygen, dead vegetal matter would not yield to oxidation and decay. Were we seeing dead vegetal matter when the Syrtis turned black? Strong evidence indicates that the colors are largely intrinsic, but the atmosphere may tinge the markings to some extent as a function of depth in altitude and haze variation. For the time being, we must merely wonder and conjecture about life on Mars. The long-time question of the meaning of the Martian canals, however, now lends itself to reasonable interpretation.

During the past 25 years, important

contributions to our knowledge of physical conditions on Mars were made by various astrophysicists, who measured temperatures with new devices and methods, analyzed the atmosphere with more powerful spectroscopes and polarimeters, and re-evaluated various data in the light of new findings in physics. The sum total of this new knowledge reduced Mars to a world much more harsh than was previously thought. The idea of an intelligent race of Martians faded away. The canals were relegated to optical illusions.

30 Years of Study

But, during 30 years study of Mars, I had seen over 100 of the controversial canals too well, with telescopes of great effective power, to dismiss them as unreal. This study included the canals in relation to the oases and maria. Comparison of the canals to volcanic dikes and fissures was found to be wholly inadequate, and was subsequently abandoned.

But, during 30 years' study of Mars, Since 1932, a dozen small asteroids were accidentally discovered whose orbits crossed the Earth's, with aphelia beyond the orbit of Mars. If several were discovered accidentally near the Earth, how many hundreds, unobserved, cross the orbit of Mars? The idea was very suggestive.

Over the ages, Mars must have been hit by many asteroids. Such dreadful collisions must have produced some visible marks. It was tempting to compare the resemblance of the canals to the radial fractures produced by a stone hitting a car windshield.

In macroscopic proportions, igneous rock is isotropic in strength, unlike sedimentary and metamorphic rocks. Therefore, under sudden shock, as would be produced by an asteroid hit, the igneous rock should fracture like glass. Collisions with asteroids a few miles in diameter going at velocities of the order of 15 mps might well fracture a planet to the bottom of its crust and to radial distances of hundreds or even a few thousand miles. Here it should be noted that, because of its lesser gravity than Earth's, the Martian crust might be as much as 100 miles thick.

Where a fracture line met the surface, a long narrow strip of shattered rock would be produced, and would offer some haven to a hardy form of vegetation. This may well explain the existence of radial canal patterns and, also, their seasonal visibility produced by the moisture wave from the summer polar region. The oases, then, would be impact craters surrounded by concentric zones of scattered rock

—again, a haven for vegetation—to make dark contrast against a light felsite rock terrain.

But this is not all. It had long been noted that the maria were angularly shaped quadrilaterals and triangles, slender and broad, small and large. A planet crisscrossed with shear-lines would allow crustal blocks to move up or down in response to the internal pressures of diastrophism. There is strong evidence that this has occurred on Mars. The maria are sunken blocks (known as grabens). Some appear to have subsided to a constant depth. Others appear to be deep at one end, becoming more shallow at the other. A shallow end may be regarded as the axis of a vast diastropic hinge. Pronounced examples of such hinges are found in the middle of the Syrtis Major, at the southern end of the Margaritifer Sinus, and many other places. The locations and orientations of these hinges are revealed by the premature thinning out of vegetation toward the close of the vegetal-darkening season.

Some maria—such as the Syrtis Major and the Mare Acidalium—do not have fracture lines from a single asteroid impact. Such impacts may have been separated in time by millions of years. The northwest coastline of the Syrtis is a perfect continuation of the Nilotis canal emanating from the impact that created Nilus Lucas, to the north of the Syrtis tip. The northeast coastline of the Syrtis is a continuation of the Astusapes canal emanating from Pseboas Lucus. The southwest coastline of the Syrtis is at an angle with the northwest coastline, and the former appears to be in a radial line with an oasis within the north central part of the Syrtis.

To Martian northwest, from the Trivium Charontis, lies a vast plateau called Elysium, which is probably the highest land on the planet. The area is sharply pentagonal in shape, bounded by five long canals, two of which are common to two sides of the Trivium Charontis. Except for the relatively small neighboring Trivium, the remainder of the surrounding area is desert. The northern 20 deg parallel runs through the center. The corners of the pentagon extend 600 geographical miles from the center.

During most of the Martian year, Elysium appears much the same as the surrounding desert. By midsummer of the northern hemisphere, this area becomes white with frost except around noon. The eastern side, next to the Trivium, gets white first. Frequently the whitening develops over the entire area, but it always stops abruptly at the edges of the pentagon.

One is forced to conclude that the

five sides represent enormous vertical escarpments—and just where we should expect them—along the canals. I have many times seen the entire Elysium in its late Martian afternoon as intensely white as the oval polar cap, but five-sided in shape. Because of the lesser gravity on Mars, its atmospheric density gradient must be less abrupt. To produce such an outstanding meteorological difference must surely require altitude differences of many thousands of feet.

Significant Factors

The distribution of the maria and desert highlands is also significant. When the Martian surface markings are plotted on a globe, the pattern becomes striking indeed. It is noted that there are three major regions of maria in the southern hemisphere and three minor ones in the northern hemisphere. Those maria in the south are approximately centered along the 25 deg parallel. Those in the north lie along the parallel of 45 deg. In each respective hemisphere, the maria are spaced about 120 deg apart in longitude. Curiously, the lesser maria of the north have the same longitudes as southern counterparts. The great expanses of Martian desert are centered along the north 25 deg parallel, also spaced 120 deg apart in longitude, but staggered so as to occupy intermediate positions with respect to the maria in both hemispheres. The pattern is remarkably tetrahedral.

What does this mean?

If we assume that the interior of Mars slowly lost heat during its past ages, there should have been a small amount of global shrinking. A spherical planet will deform in a way that will involve the least disturbance. In shrinking, then, Mars should develop a tetrahedral pattern, because the forming of the tetrahedron (solid geometric with least volume for surface area) would cause minimum change to its surface, i.e., minimum crustal buckling. A tendency for the surface to buckle would also be opposed by a thick crust and the short crustal radius of curvature. Tetrahedral collapse of the surface of Mars should thus be expected, and so it is found.

On Mars, the maria represent the faces of the tetrahedron while the desert highlands represent the vertices. It was mentioned earlier that three great desert areas were centered along the north 22 deg parallel. Where is the fourth vertex? It is very near the south pole, where one would expect it. Indeed, another dissimilarity between the Martian north and south polar caps appears to be explained by it. Unlike the north cap remnant, which centers

on the geographical pole of rotation, the south polar cap is off center by 6 deg. An up-thrust crustal block (known as a horst) in this region would displace the pole of cold from the pole of rotation. This is a strong indication of the presence of the fourth vertex. A north polar face would favor centering of the polar cap. With the three great maria in southern low latitude, the north polar region constitutes the fourth face, and it is just where we should expect it to be located. This comprises the major tetrahedral deformation of the Martian globe.

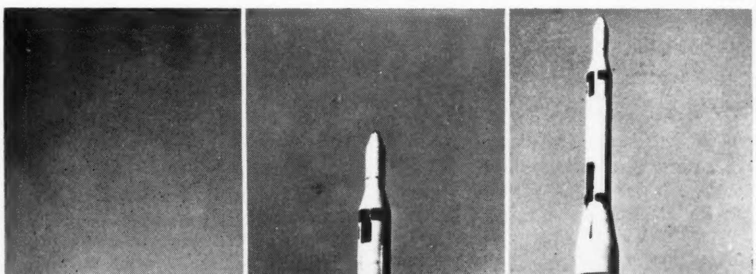
The distribution of ocean basins and continents on Earth exhibit a similar tetrahedral pattern.

The lack of sterile salt deposits and dendritic erosional patterns is pretty strong evidence that Mars never had oceans, hence never very much water. There can thus have been no explosive volcanism depending on superheated steam.

Without oceans, water erosion, and volcanos, Mars must have a geology much less complicated than ours—one lacking sedimentary beds of rock, erosional carving (which gives our familiar talus slopes, valleys, and canyons), exposed metamorphic rock, and the kinds of minerals and rocks formed through sedimentation and metamorphism, and so forth.

The planet, moreover, must lack our familiar high-level sources of energy. That prime source, solar energy, averages a little less than half on Mars what it does on earth. The geological conditions preclude the formation of coal and oil. The quantity of fuel from the scanty vegetation must be pitifully small, and the atmosphere too poor in oxygen to sustain much combustion. Thus the planet lacks a major means to smelt ores and to drive machinery. Sobering thoughts to those who are so sure that intelligent beings similar to us inhabit Mars.

Then why should we be interested in making a trip to Mars? All of these differences should only make Mars more fascinating to study. A manned landing on Mars would be a momentous achievement for the human race. It would be a field day for the geologist, biologist, astrophysicist, and meteorologist. They would glean knowledge on the consequences of a set of physical conditions foreign to us. This knowledge would help us to understand better our own planet, and to exploit further the Earth's resources for the benefit of mankind. Most important, to see at first hand what Nature has done with a world so marginal for life would be of the greatest philosophic and religious value, in helping us to understand our place and our purpose in the Universe.



Polaris on the Move

Last June, Lockheed took these pictures of a limited-objective Polaris launching at Cape Canaveral. Navy expects Polaris to be operational from nuclear-powered submarines in 1960.

Government contract awards

Martin Gets $20 Million Bullpup Production Job

A $20.4 million dollar Navy contract for the production of the ASM Bullpup, and other necessary services and materials, has been awarded to The Martin Co.'s Orlando, Fla., Div.

NAA Awarded First GAM-77 Production Contract

An $18.9 million AF contract for initial production of the ASM GAM-77 has been awarded North American Aviation's Missile Div., which received the initial research and development contract for the program in 1957.

Jupiter Theodolites

Perkin-Elmer Engineering and Optical Div. has received $1.5 million in subcontracts for alignment theodolites to be used for the Jupiter program.

Hypersonic Research

Cornell Aeronautical Lab, under $66,000 and $61,000 contracts, respectively, with Wright Air Development Center, is conducting a study of thermal and aerodynamic characteristics during hypersonic flight and of hypersonic drag devices to provide safe recovery of space vehicles. CAL will also explore the feasibility of extending the operating range of hypersonic shock tunnels to velocities over 15,000 mph and altitudes of 300,000 ft.

Advanced Firebee Contract

The Air Force has awarded Ryan Aeronautical a $2.4 million contract for first phase production of an advanced version of the Firebee jet target drone, designated Q-2C. The full project is expected to approximate $10 million and to extend into 1960.

Photo shows greater over-all length, wing area, and power of new Q-2C Firebee over its predecessors.

Coatings for Mach 5 Flight

An Air Force study contract of $134,000 to analyze and develop protective coatings, capable of radiating heat at temperatures up to 2400 F encountered in Mach 5 speeds, has been awarded to Republic Aviation.

Massive Handling Unit

The Hufford Corp. has received a $225,000 contract from Thiokol Chemical for development and production of a mobile rocket engine handling device, to be known as "Transrector," that will be capable of handling engine units up to 35 ft long, 85 in. in diam, and weighing 80,000 lb.

AMF Gets Titan Contract

American Machine and Foundry has received a $29.3 million AF contract for design and development of a launching system for Titan.

Bomarc Guidance Beacon

Boeing has awarded Motorola Military Electronics Div. a $714,636 contract for continuance of its Bomarc guidance beacon program.

Sage Data Systems

The Air Force has let a $22,817,000 pact to Burroughs Corp. for an additional 32 data processing systems in the Sage program.

ABMA Contract

ABMA has awarded Consolidated Electrodynamics contracts calling for a high-altitude simulation system and for research and development studies in extending the application of high vacuum in the simulation of high-altitude conditions.

Tracking Computers

Aerojet-General has let a $65,000 contract to Mid-Century Instrumatic for missile tracking computers and plotters for the new Navy-managed National Pacific Missile Test Range, Pt. Mugu, Calif.

Electronic Countermeasures

Sylvania Electronic Systems has received an engineering study contract (unspecified amount) for research on radar jamming techniques.

Geni Components

Douglas has awarded Electronic Specialty Co. a $600,000 follow-on contract for production timers used in fuzing the Geni missile.

$33 Million Tacan Contract

Air Materiel Command has awarded Hoffman Electronics a $33 million contract for development and production of improved Tacan (Tactical Air Navigation) equipment.

SYNOPSIS OF AWARDS

The following synopsis of government contract awards lists formally advertised and negotiated unclassified contracts in excess of $25,000 for each Air Force, Army, and Navy contracting office:

AIR FORCE

Comdr., Hq, AMC, Wright-Patterson AFB, Ohio

Research in supersonic environment for phase I development program for B-70 weapon system, $9,099,998, **North American Aviation,** International Airport, Los Angeles 45, Calif.

Missiles, spare parts, technical data, handbooks, and bill of materials, $20,000,000, **Northrop Aircraft,** Northrop Div., Hawthorne, Calif.

Facilities for the WS-315A ballistic missile, $475,000, **Douglas Aircraft,** Santa Monica, Calif.

Aircraft nuclear propulsion program, $39,369,000, **General Electric,** Aircraft Nuclear Propulsion Dept., Evendale, Ohio.

Hq, AF Cambridge Research Center, ARDC, USAF, Laurence G. Hanscom Field, Bedford, Mass.

Research services related to re-entry physics and instrumentation radar, $4,500,000, MIT, Cambridge, Mass.

Research directed toward investigation of the physics, dynamics, and general properties of the ionosphere, $75,000, **Pennsylvania State Univ.,** University Park, Pa.

Research directed toward the study of radiation of electromagnetic waves, $49,982, **Brown Univ.,** Providence, R. I.

Portable trailer, field laboratory, $95,162, **Dynatronics, Inc.,** 717 W. Amelia Ave., Orlando, Fla.

Design and fabrication of meteorological rocket balloons, $34,458, **G. T. Schjeldahl Co.,** Northfield, Minn.

Research directed toward the understanding of hydromagnetic shocks, $25,000, **MIT,** Cambridge, Mass.

Aeronautical engineering instrumentation development, $29,953, **Allied Research Associates, Inc.,** 43 Leon St., Boston, Mass.

Research in magnetohydrodynamics and its astrophysical applications, $34,729, **Harvard College,** Cambridge, Mass.

Research directed toward engineering services for instrumentation of rockets, $119,997, **Wentworth Institute,** 50 Huntington Ave., Boston, Mass.

Hq, AF Office of Scientific Research, ARDC, Washington 25, D.C.

Research on the theory of composite propellant burning, $46,575, **Lockheed**

Aircraft Corp., Missile Systems Div., Sunnyvale, Calif.

Research on selected problems in microwave electronics, $38,500, **Cal Tech**, Pasadena, Calif.

Research on strong luminous shocks produced in shock tubes, $27,150, **Univ. of Michigan**, Ann Arbor, Mich.

Research on molecular problems in heat and mass transfer, $46,000, **Princeton Univ.**, Princeton, N.J.

Research on extensive air showers in the cosmic radiation, $43,000, **Univ. of New Mexico**, Albuquerque, N.M.

Research on nuclear emulsion research with high-energy accelerators, $77,870, **Univ. of Chicago**, Chicago 37, Ill.

Research on methods and techniques for space flight, $49,951, **Westinghouse Electric Corp.**, Baltimore, Md.

HQ, PATRICK AFB, ARDC, USAF, PATRICK AFB, Fla.

Increase in funds, $68,670, **Nems-Clark Co.**, 919 Jesup Blair Dr., Silver Spring, Md.

Increase in funds, $375,000, **General Dynamics**, San Diego 12, Calif.

Increase in funds, $27,172, **The Perkin-Elmer Corp.**, Norwalk, Conn.

HQ, REDSTONE ARSENAL, U.S. ARMY ORDNANCE MISSILE COMMAND, Ala.

Fabrication of T-273 rocket motors and T-273 rocket war heads, $38,446, **Norris Thermador Corp.**, 5215 South Boyles Ave., Los Angeles, Calif.

Transducers, $25,200, **Wiancko Mfg. Co.**, 225 N. Halstead Ave., Pasadena, Calif.

Design, develop, and fabricate 17 rocket motor cases, $33,815, **Norris Thermador Corp.**, 5215 South Boyles Ave., Los Angeles 58, Calif.

SAN ANTONIO R&D PROCUREMENT OFFICE, WADC, ARDC, USAF, Box 63, Lackland AFB, Tex.

Design, development, fabrication, and installation of a space cabin simulator, $179,928, **Minneapolis-Honeywell Regulator Co.**, Aeronautical Div., 2600 Ridgway Rd., Minneapolis 13, Minn.

ARMY

CLEVELAND ORDNANCE DIST., 1367 E. Sixth St., Cleveland 14, Ohio.

Research on satellite ionization phenomena and observations, $35,000, **Ohio State Univ. Research Foundation**, 1314 Kinnear Rd., Columbus 8, Ohio.

PURCHASING AND CONTRACTING DIV., WHITE SANDS MISSILE RANGE, N.M.

Target for LaCrosse, White Sands Missile Range, N.M., $41,950, **Goldberg & Lavis**, 111 E. Franklin St., Room 205, El Paso, Tex.

U.S. ARMY DIST., 55 S. Grand Ave., Pasadena, Calif.

Research and development, $2,095,000, **Cal Tech**, Jet Propulsion Lab, 4800 Oak Grove Dr., Pasadena, Calif.

Research and development for miniaturization work, $690,536, **Motorola, Inc.**, Western Military Electronics Center, Phoenix, Ariz.

Research and development work, $509,952, **Rheem Mfg. Co.**, 9236 E. Hall Rd., Downey, Calif.

Research and development, $334,000, **North American Aviation**, Rocketdyne Div., Canoga Park, Calif.

Missile repair parts, $280,699, **Douglas Aircraft**, 3000 Ocean Park Blvd., Santa Monica, Calif.

Transducers, $93,650, **Topp Mfg. Co.**, Los Angeles, Calif.

Research and development, $25,024, **Aerophysics Development Corp.**, Santa Barbara, Calif.

NAVY

DEPT. OF THE NAVY, BUAER, Washington 25, D.C.

Services and materials necessary for testing, handling, repair, rework and/or modification of the AAM-N-6 Sparrow III guided missile, $833,839, **Raytheon Mfg. Co.**, Waltham 54, Mass.

NAVY DEPT., BUORD, Washington, D.C.

Launcher loading stands for Terrier BWO-BWI and BT 3 missiles and their companion boosters, $352,229, **Baker Industrial Trucks**, a Div. of Otis Elevator Co., Cleveland, Ohio

OFFICE OF NAVAL RESEARCH, Washington 25, D.C.

Minitrack satellite tracking station units, $589,355, **Bendix Radio Div.** of Bendix Aviation Corp., Baltimore, Md.

Research on curved jets, $28,345, Dr. Gabriel Boehler/dba/**Aerophysics Co.**, Washington, D.C.

U.S. NAVY PURCHASING OFFICE, 1206 S. Santee St., Los Angeles 15, Calif.

Telemetry system and components, $48,730, **Electro-Mechanical Research, Inc.**, Sarasota, Fla.

Data reduction analysis service at the U.S. Naval Ordnance Test Station, China Lake, Calif., $127,598, **Associated Aero Science Laboratories**, 250 South Prairie Ave., Hawthorne, Calif.

Telemetering equipment, $87,510, **Applied Science Corp. of Princeton**, Princeton, N.J.

Project Squid Prepares for 14th Year

Project Squid, which began in 1946 under the sponsorship of ONR and the direction of Princeton Univ., enters its 14th year beginning Oct. 1, 1959.

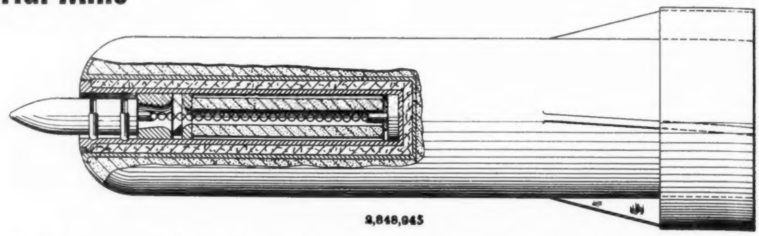
The Squid program covers basic and applied research into the fundamentals of rocket and jet propulsion and theoretical and experimental work on such related subjects as heat, mass, and momentum transfer, chemical kinetics, fluid mechanics, and thermodynamics.

Proposals for contributing to the Squid program will be accepted until Jan. 30, 1959. Write Project Squid, James Forrestal Research Center, Princeton Univ., Princeton, N. J.

From the patent office

By George F. McLaughlin

Rocket Motor Decelerates Aerial Mine



Elevation view and partial section illustrating the rocket motor deceleration system installed in an aerial-launched mine.

The parachute method of decelerating an aerial-launched mine during a mine planting operation has not proved satisfactory, particularly when the mine is released from high altitude and deployed from a direct-opening chute. In such a case, the chute causes the mine to drift off course and prevents accurate planting. A delay-opening chute requires complicated and sometimes unreliable control devices and equipment.

A deceleration device for overcoming these disadvantages has been assigned to the U.S. Navy, which may manufacture and use the device without paying royalties. It consists of a rocket motor and a fuze within a well along the longitudinal axis of the mine casing.

The motor comprises a tube secured to the casing and containing a propellant charge. There is a nozzle within the tube at the nose end of the mine and a squib and igniter within the tube and arranged at one end of the charge. The fuze is releasably mounted in the forward end of the tube by a pair of resilient elements disposed about the casing and in frictional engagement with the tube, the fuze being electrically connected to the squib by a pair of conductors.

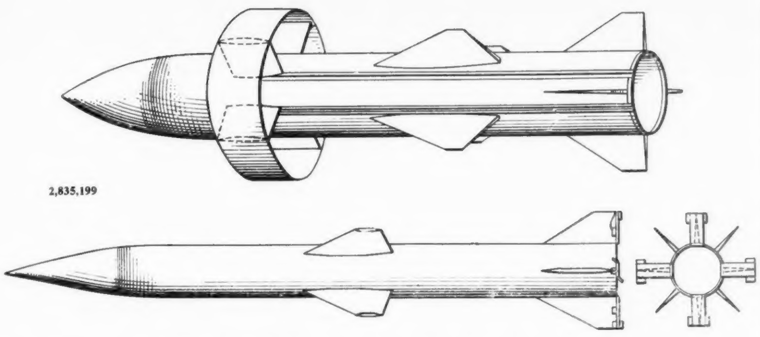
The fuze may be a well-known conventional VT type, rendered operable by the withdrawing of an arming wire as the mine is released from an aircraft. When this occurs, the fuze operates in response to water reflections at a preset height, sending an electrical impulse to the rocket-motor squib.

The squib fires the igniter, and thence the propellant charge. When the propellant ignites, the fuze is forcibly ejected through the nozzle. The backward thrust of the rocket motor slows the mine sufficiently to permit it to enter the water without damage.

Patent No. 2,848,945. Rocket Decelerated Mine. Donald Q. Brumbaugh, Hyattsville, Md., assignor to the U.S. Navy.

Navy's New Arcas Research Rocket

Atlantic Research Corp. engineer holds the company's new Arcas solid propellant research rocket, developed for the Navy. To be used in ONR meteorological and upper-atmosphere research work, Arcas weighs only 72 lb and can easily be carried to its portable launcher. The 6-ft, single-stage vehicle is said to be capable of taking a 12-lb payload to an altitude of 40 miles. At the end of its flight, the nose cone, carrying the instrumented payload, is parachuted back to earth.



Two versions of missiles designed to be launched rearwardly.

Stabilizing a Missile Fired Rearward from Aircraft

To be aerodynamically stable, a body—in this instance, a missile—must have its center of pressure (CP) aft of its center of gravity (CG) with respect to the direction of ambient air flow. It follows that a missile launched rearward from an aircraft will experience an initial instability, perhaps tumbling or erratic slewing. That is, the missile will move for a short time in the direction of the aircraft, even though its nose is pointed rearward, and the normal positions of its CP and CG will be reversed in relation to ambient air flow. The missile fired rearward rides at first in a "negative" ambient air flow, accelerates through zero velocity with respect to ambient air, and finally reaches a condition of stable flight—greater velocity than the ambient air in terms of launching conditions.

The invention provides a missile aerodynamically stable in this "negative" air flow at launching. The missile, as shown in the diagram above, has two sets of fixed fins spaced about the tail and center section, which stabilize the motion of the missile in normal forward flight, and a jettisonable wing unit, which stabilizes the missile in rearward launching.

The jettisonable wing, which rides toward the missile nose, forward of the CG, consists chiefly of a cylinder, coaxial with the longitudinal axis of the missile, and supporting radial struts. The cylindrical wing and struts furnish enough lift to shift CP forward of CG in a "negative" air flow. The wing also gives relatively high drag, which is transmitted as a force toward the nose of the missile. When ambient air flow is negative, this drag maintains the jettsionable wing in place. But, as the missile accelerates and approaches relative air velocity of zero, drag forces on the cylindrical wing also approach zero; and, as the missile rides through "zero" and then experiences positive air flow, drag forces shift in effect from the nose to the rear of the missile. This rearward shift of the drag forces and the force of acceleration causes the wing unit to slide off the missile, and loss of the cylindrical wing causes the CG of the missile to shift to the proper place for forward flight. The release of the cylindrical wing can be controlled—for example, by friction pins or bolts actuated by delay-action squibs, as well as by drag and acceleration.

Patent 2,835,199. Stabilized Self-Propelled Missile. Albert L. Stanly, Los Angeles, Calif., assignor to Hughes Aircraft Co.

Liaison for NASA and Military Services

By White House appointment, William M. Holaday, DOD missile czar, will head the Civilian-Military Liaison Committee, set up to arbitrate disputes over roles and missions between NASA and the military services. Other committee members: Roy W. Johnson, ARPA; Maj. Gen. R. P. Swofford, AF; Maj. Gen. W. W. Dick, Army; Vice Adm. R. B. Pirie, Navy; and Hugh Dryden, Abe Silverstein, Homer Stewart, and Ira Abbott, NASA.

ARPA Contracts for Solids

The Advanced Research Projects Agency recently negotiated \$1-to-2 million contracts with Dow Chemical, Esso Research and Engineering, 3M, and American Cyanamid for research on basically new high-energy solid propellants, and the necessary testing to show I_{sp} and combustion properties.

New equipment and processes

Plasma Arc Torch Fabricates Shapes, Applies Coatings and Simulates Re-entry Conditions

Linde Co. has introduced a new method for using its patented Plasma Arc Torch in fabricating shapes and applying coatings that will withstand temperatures above 5000 F. Harnessing temperatures up to 30,000 F, the method makes possible fast and accurate mass production of refractory materials, in the past virtually unworkable by conventional means.

Key to the method is a device less than 2 in. in diam that melts ultra-hard materials without being itself consumed by the intense heat it generates. Among these materials are pure tungsten, molybdenum, zirconium, tantalum, hard carbides, and certain precious metals.

The material to be worked is prepared in either wire or powder form and then passed through an intense arc struck inside the torch. Inert gas carries the material, now converted to a fluid or plastic, out of the torch and deposits it, with the aid of coolant CO_2 spray, at near sonic velocity on the part being made or plated. Coatings made with the torch are very dense, usually laminar, and can be finished to below 10 microinches.

Multiple coatings can be used to build components, such as tungsten crucibles and nozzle liners. Coated parts made by this method are finding many applications in the electronic industry—as tungsten heaters, grid bars, cages, etc. This technique has also been utilized as a wind tunnel aid—to produce visible shock waves and re-entry conditions.

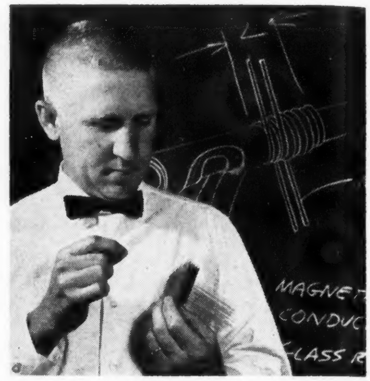
In a typical use, Linde Plasma Arc Jet applies successive coatings of tungsten on a spinning mandrel until desired thickness is reached. Then mandrel is dissolved with acid, leaving part—a nozzle liner for a rocket engine—ready for finishing operations.

Missile Gage

This gage for missile bodies holds a tolerance of ±0.003 in. over its nearly 9 ft diam. The gage, designed and built by Air-Auto Industries of Lansing, Mich., is made of epoxy-resin reinforced fiber glass to keep its cost and weight low and make its handling easy. The circumference holds 50 steel inserts as check points.

Computer Element Promises Advances

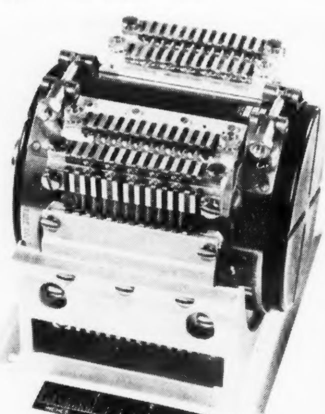
A digital-computer element that both stores information and acts as a switch has been invented and developed under the direction of Donald A. Meier of National Cash Register's Electronics Div. Comprised of a wire-wound glass rod with a magnetic coating, the element, which operates in either word-ordered and coincident-current circuits, draws only 20 thousandths of a watt to store a bit, stores 1000 bits per cu in., switches in 4 millimicrosec, operates in coincident-current modes from −100 to 200 C, and takes continuous switching at a 5-mc repetition rate without adverse heating effects in laboratory models. Because of its very rapid switching rate, low power rating, and wide temperature limits, this computer element should find many uses in control equipment for missiles and satellites, es-



pecially the latter in view of its low power consumption. Typical applications being studied now by NCR include a high-speed memory with 1 μ sec cycle time, shift register and counter that work in the range 2–5 mc, and multipropositional logic systems.

Electronic Commutator: Solid-state high-speed device for commutating up to 1000 channels of information at rates of 100,000 samples per sec. Commutates either a.c. or d.c. signals to a voltage-to-digital converter, or the reverse. Packard-Bell Electronics Corp., Technical Products Div., 12333 W. Olympic Blvd., Los Angeles 64, Calif.

Power-Density Meter: Portable unit with hand-held probe for measuring high-energy microwave fields; detects hot spots and leakage areas around antennas, transmitter tubes, and plumbing. Sperry Microwave Electronics Co., Div. of Sperry Rand Corp., Clearwater, Fla.



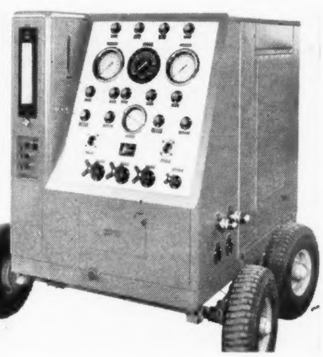
Vibration Control: System for controlling vibration by absorbing it through a network of stainless-steel

cable. Straight-line motion under high accelerations. T. R. Finn & Co., Inc.

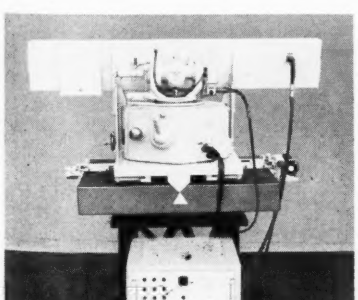
Miniature Connectors: Snap-in electrical connectors with removable contacts, silicone inserts, and crimp-type terminations that replace solder pots. Mated connectors withstand -100 to 300 F. Deutsch Co., 700 Avalon Blvd., Los Angeles 3, Calif.

Photoconductive Cells: Miniature units having a sensitivity to light flux about 1 million times that of high-vacuum photomissive tubes. Power dissipation 50 mw for plastic and 75 mw for glass units, with ambient temp from -50 to 75 C. Clairex Corp., 19 W. 26 St., New York 10, N.Y.

Frame-Grid Tube: Featuring a fine tungsten gridwire which has only an electronic function, the mechanical being supplied by a self-supporting frame. Grid-to-cathode spacing is reduced to 0.05 mm, giving high gain bandwidth product. Amperex Elecgronic Corp., 230 Duffy Ave., Hicksville, L.I., N.Y.



Hydraulic Test Cart: Self-contained portable unit for missile production checkout. Delivers 10 gpm of clean oil at pressures up to 3000 psi and provides automatic back-pressure on the missile hydraulic system to within ±1 psi. G. L. Nankervic Co., 15300 Fullerton Ave., Detroit 27, Michigan.



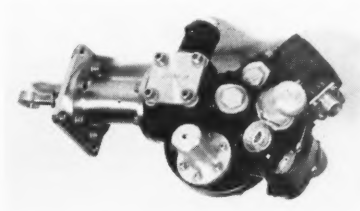
Electrotheodolite: Optical instrument to monitor azimuth alignment of missiles during pre-launching period. Spectrometer base, 20 in.; accurate within 1 sec of arc. Davidson Mfg. Co., 2223 Ramona Blvd., W. Corina, Calif.

Automatic Electronic Focusing: Optical Automatic Ranging (OAR) system developed for simple ranging or distance determining devices for aircraft and missiles, anti-collision equipment, and ground elevation indicators for terrain and strip cameras. Comapco Inc., 17071 Ventura Blvd., Encino, Calif.

Ka-Band Magnetrons: Three new Ka-band (33–36 kmeg frequency) magnetrons for radar equipment used in cloud finding, mapping, and missile guidance. The 20-kw M4063 weighs 9 lb; the 40-kw M4155, 11 lb. Sylvania Electric Products Inc., 1740 Broadway, New York 19, N.Y.

Insulating Tube: Protection for cables, wires, and tubing from corrosive effects of hydraulic fluids and high temperatures—the tubing combines in one lamination the chemical and tensile qualities of Mylar, the reflective quality of aluminum, and the abrasion and tear strength of vinyl. The Zippertubing Co., 752 S. San Pedro St., Los Angeles 14, Calif.

Data Transmitter: Transmits highly accurate data over standard fm/fm telemetering systems. Based on a quantizer and differential amplifier which continuously separates an input voltage into 16 discrete levels. Hoover Electronics Co., 110 W. Timonium Rd., Timonium, Md.



Rocket Thrust Controller: Hydromechanical controller for sensing and correcting small errors in thrust-chamber pressure in liquid propellant engines by producing a rate of change in actuator position. Bendix Products Div., Bendix Aviation Corp., South Bend, Ind.

Oxygen and Nitrogen Converters: Ten-liter aluminum and stainless-steel converters designed to operate at 300 psi. Powder-vacuum insulation minimizes evaporation loss. Linde Co., Div. of Union Carbide Corp., 420 Lexington Ave., New York 17, N. Y.

LITERATURE

Packaged Laboratories for Environmental Production Testing, Bulletin 6. Wyle Associates, 128 Maryland St., El Segundo, Calif.

Near-Infrared Transmission Filters, Report No. 3. Bausch & Lomb Optical Co., Rochester 2, N. Y.

Lead Sulfide Photoconductors, Bulletin 2. Infrared Industries, Inc., P.O. Box 42, Waltham 54, Mass.

Graph for Computing Cumulative Errors in Electronic Clocks. Hycon Eastern, Inc., Cambridge 42, Mass.

Electronic Sealants and Molding Compounds, Data Chart. Coast Pro-Seal & Mfg. Co., 2235 Beverly Blvd., Los Angeles 57, Calif.

Missile Scoring Systems. Triad Corp., 17136 Ventura Blvd., Encino, Calif.

Microwave and UHF Electronic Test Equipment. Narda Microwave Corp., 118 Herricks Rd., Mineola, N.Y.

Inert Gas Process Weldor's Training Manual. Kaiser Aluminum & Chemical Sales, Inc., 919 N. Michigan Ave., Chicago 11, Ill.

Transistorized Converters. Transicon line of analog-to-digital converters, digital-to-analog converters, and alarm limit monitors. Epco, Inc., 599 Commonwealth Ave., Boston 15, Mass.

Hollow Aluminum Bar Stock. Detailed information on standard sizes available in round and hexagonal machining stock. Harvey Aluminum, 19200 S. Western Ave., Torrance, Calif.

Electronic Computing Machine. Engineering applications, such as numerical evaluation of integrals and linear differential equations with constant coefficients. Clary Corp., San Gabriel, Calif.

Toroids and Filters. Catalog 104 gives schematics and performance curves on coils, delay lines and other networks. Burnell & Co., Inc., 10 Pelham Pkwy., Pelham, N.Y.

Titanium Tubing. Physical and mechanical properties, fabrication, and corrosion resistance of titanium tubing and pipe. Applications in aircraft and chemical fields cited. The Carpenter Steel Co., Alloy Tube Div., Union, N.J.

Wires and Cables. Comprehensive listing including custom built types available for rocket, missile and ordnance systems. Publication 19-268. General Electric, Bridgeport 2, Conn.

Microwave Equipment. Gives specifications on load isolators, duplexers and switches. Cascade Research Div., Monogram Precision Industries, Inc., Los Gatos, Calif.

Thermocouple Tables. Indexed booklet to facilitate use of company's heated-type thermocouple reference junction. Pace Engineering Co., 6914 Beck Ave., N. Hollywood, Calif.

Electrical Products. Catalog of connectors, terminals, blocks, insulators, staples, knock-out plugs and other products and tools. Buchanan Electrical Products Corp., Hillside, N.J.

Drift Transistors. Brochure G-180, specifications on seven PNP drift transistors. General Transistor Corp., 91-27 138th Pl., Jamaica 35, N.Y.

Acoustical Vibration Testing. High intensity testing as applied to aircraft and missile components and structures. Bulletin C-2. Rototest Laboratories, Inc., 2803 Los Flores Blvd., Lynwood, Calif.

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